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Given the limited total resources available to USAF Civil Engineering, a means of systematically measuring and reporting productivity levels and trends is needed by base level civil engineering design section managers to compare and evaluate relative efficiency. These measures can aid in allocating resources to the best advantage of the Air Force. Thus, the purpose of this research was to (1) develop specific output measures which relate to organizational goals and objectives for the design section of a base level USAF civil engineering organization; (2) develop productivity measures based on these output measures and input measures currently documented by the design section; and (3) determine what productivity measures are considered appropriate by managers in the field to measure progress towards the operational objectives of the design section. The first two objectives were satisfied through an extensive review of pertinent literature. The third objective was accomplished through the use of a questionnaire to gather sufficient data to identify useful productivity measures. An analysis of the data identified six measures perceived by base level civil engineering managers to be appropriate for the design section. Relevant conclusions and recommendations were drawn.

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DEVELOPMENT OF PRODUCTIVITY MEASURES FOR THE DESIGN SECTION OF A BASE LEVEL CIVIL ENGINEERING ORGANIZATION

A Thesis

Presented to the Faculty of the School of Systems and Logistics

of the Air Force Institute of Technology

Air University

In Partial Fulfillment of the Requirements for the

Degree of Master of Science in Facilities Management

By

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Chapter 1

INTRODUCTION

PRODUCTIVITY IN THE FEDERAL GOVERNMENT/ DEPARTMENT OF DEFENSE

The United States Government is one of the largest "businesses" in the world with annual expenditures in the billions of dollars and with hundreds of thousands of employees. Yet the government differs from even the smallest businesses in the private sector for one reason: the profit motive. This lack of a profit motive denies government managers the opportunity to state objectives in monetary terms. Goals stated in monetary terms are relatively easy for top management to promulgate and for subordinate managers to agree on. Additionally, the profit orientation provides an overriding goal which is clearly discernible throughout all subsequent levels of control. Within the government sector, managers must attempt to substitute profit margin measures with more intangible goals such as "national defense" (in the case of DOD). This difference has been pointed out by Mundel in the following manner:

> In upper-level control cycles in industry (top management controls), objectives are usually stated in net economic results desired. In the case of a non-economically motivated organization, such as government, objectives are stated in social or appropriate substantive results [26:22].

Thus, within government, it is difficult to establish a clear set of quantifiable organizational objectives (at least in terms of profit).

A recent study by H. G. Rainey pointed out that government organizations, as compared to private businesses, tend to have:

> (1) greater multiplicity and diversity of objectives
> (2) greater vagueness and intangibility of objectives
> (3) greater tendency of goals to be conflicting
> (4) greater caution and rigidity, less innovativeness [31:233-244].

Since productivity is defined as a ratio of output over input with goals considered, these findings point out why it is much more difficult to establish meaningful productivity measures in government than in private industry.

Peter Drucker pointed out another difference between private business and government institutions which impacts productivity. Businesses are paid only when they produce what the customer is willing to pay for. Government institutions, in contrast, are typically paid out of a budget allocation.

> Efficiency and cost control, however much they are preached, are not really considered virtues in the budget-based institution. The importance of a budget-based institution is measured essentially by the size of its budget and the size of its staff [7].

Drucker does not recommend a better way to fund government organizations but he does believe that the inherent inefficiency can be largely offset through effective management.

One way of enhancing effective management is through the development and use of productivity measurements as will be discussed later.

Even though multiple, diverse, vague, intangible, and sometimes conflicting goals confound the development of productivity measures, these measures must be developed within government (including DOD and its branches). There is a great deal of concern about the productivity of the government sector.

> Public resources are squeezed between expanding public demands for services and the rising cost of meeting those needs, on the one hand, and a growing resistance on the part of the public to provide more resources through higher taxes, on the other. One answer to this dilemma is improved productivity [27].

The energy crisis, inflation, and increasing public interest in government expenditures have severely limited the funds available to the government and particularly to the Department of Defense and have forced government organizations into fierce competition for available tax dollars. The net result is that DOD is called upon to accomplish "more with less." The need to do more with less within the DOD is reflected in recent statistics. While the federal government's spending increased nearly $50 billion from 1972 to 1977 (in current 1977 dollars), the DOD budget allocation declined by $17 billion during the same time period (3:2). As a result, DOD has placed much emphasis on productivity (12; 21; 30).

The USAF, as a component of DOD, has also inherited this problem of doing more with less. Consequently, the concern about productivity has been reflected in many statements made by USAF leaders. Louis L. Wilson, General, USAF, summarized the Air Force's promotion of productivity while Inspector General of the USAF with this statement:

> The Air Force is facing one of the most austere times in its history. In spite of increased defense budgets our buying power has eroded, with the net result that we have to do more with less. To meet this challenge, we need to fully utilize our most costly and important resource—people—by instilling in them a sense of urgency about their important role in the conduct of the Nation's critical enterprise—national security—and in doing so we must increase their productivity [45:2].

The USAF's emphasis on the efficient and effective resource management has been constantly reflected in numerous articles published throughout the 1970s (6; 14; 15; 19; 22; 23; 32; 36; 37; 44; 45).

The need for productivity improvement has not gone unnoticed by Air Force Civil Engineering (AFCE), which is responsible for the operation and maintenance of approximately $17.8 billion worth of Air Force real property (i.e., buildings and permanently installed equipment) throughout the world. This operation normally requires an annual expenditure of approximately $1.3 billion. As these figures indicate, inefficient use of resources by AFCE organizations would have a significant impact on the overall DOD productivity level (3:).

All past Directors of Civil Engineering in the 1970s have expressed their concern for increasing the productivity of the Base Civil Engineering (BCE) work force (15; 22; 36; 37). The most recent affirmation of this concern was made by the present Director of Engineering and Services with his statement:

> It is quite apparent that the cost of resources, in particular labor and material, will continue to skyrocket in the 1980s. We will have to attack this issue by improving productivity, that is by improving the efficiency of our work through better mixes of such resources as labor, equipment, materials and time, and by improving the effectiveness of our final work products. Efficiency means the competent accomplishment of a job with a minimum expenditure of resources. Effectiveness means that the completed job satisfies its intended purpose [14:4].

General Gilbert further clarifies his position with regards to managing productivity:

> Managers at all levels will have to become more aware of the factors that impact upon productivity and possess some type of capability to assess their local condition. Each civil engineering squadrom will have to concentrate on doing each work task efficiently and to organize the entire work accomplishment process so that the results are effective in supporting the local base mission [14:4,5].

These last two statements imply the need for managers to be able to measure productivity levels.

This concern and emphasis on productivity within the Department of Defense led to the issuance of the Department of Defense Directive 5010.31, "Productivity Enhancement, Measurement and Evaluation—Policies and Responsibilities," on August 4, 1975, and its reissuance and update for continuing the DOD Productivity Program on April 27, 1979. The primary objective and scope of this program is stated as follows:

> . . . to achieve optimum productivity growth (increase the amount of goods produced or services rendered in relation to the amount of resources expended) throughout the Department of Defense. Productivity increases are vitally needed to help offset increased personnel costs, free funds for other priority requirements, and reduce the unit cost of necessary goods and services [43:1].

This DOD Productivity Program will be discussed in more detail in the Literature Review section.

In summary, the government of the United States is one of the largest "businesses" in the world, but differs from private businesses since it is a nonprofit motivated, budget-based organization. These factors make productivity measurement difficult in that goals tend to be multiple, diverse, and vague; and productivity may be influenced by budget constraints. Even so, the current economic situation and increasing public interest in government expenditures have mandated that all DOD components become more productive. Top managers within DOD and its components have recognized this fact and have directed that a DOD Productivity Program be implemented. However, before such a program can be implemented, productivity measures must be developed.

Thus, the need for output measures and subsequent productivity measures has resulted from the need to make the most efficient use of manpower, money, materials, equipment, and time (inputs) in order to achieve organizational objectives. Base level managers attempt to solve this problem by devising their own organizational and operational techniques. Productivity throughout AFCE would be enhanced if base level managers were to communicate with each other on the nature and merits of varied management techniques which have been tried. One basic reason why satisfactory communication is not possible at present is the lack of quantitative and applicable standards of productivity measurement. An attempt to contribute to productivity improvement by considering and evaluating approaches to the development and use of adequate productivity measurements for the appraisal of work within the design section of a BCE organization is needed and is the subject of this thesis. Before this attempt is discussed in any further detail, a review of the general structure and goals of the design section of a BCE organization is needed.

STRUCTURE AND GOALS

The design section of a BCE organization is just one part of a world-wide AFCE organization whose mission is to "acquire, construct, maintain, and operate real property facilities and provide related management, engineering, and support work and services [40:2]." The Engineering and Environmental Planning Branch (DEEP), of which the design section (DEED) is a part, contributes to this overall mission by assuming the responsibility of the design of facility projects, construction management, technical reviews of project documents/designs, professional engineering consultant services, and technical studies. A recent thesis by Baumgartel and Johnson (3) identified the following objectives for DEED:

1. Facility Life Cycle Cost
   A. Identify and program Military Construction Projects (MCP) projects, and monitor approval, design and construction phases to ensure maximum durability and maintainability of accepted facilities.
   B. Ensure in-house design complies with AFM 88-15 and applicable building codes.
2. Facility Function
   A. Ensure new construction projects are identified, programmed and designed in a timely manner, and are designed and located in accordance with the user's requirements.
   B. Identify, program, and design contract corrections to facilities which are functionally inadequate for mission requirements.
3. Facility Protection
   A. Ensure corrective contract actions for identified facility fire, safety, and security deficiencies are programmed, designed, and completed in a timely manner.
   B. Ensure new contract work complies with regional requirements for structural protection against weather and earthquake-related forces.
4. Facility Occupant/User Requirements
   A. Complete architectural studies of facilities to identify inadequate aesthetic conditions and facility deficiencies contributing to occupant discomfort.
   B. Ensure designed projects comply with applicable life safety and public health code requirements.
   C. Ensure identified facility life safety and health code deficiencies requiring contract corrective action are programmed, designed, and completed in a timely manner.
   D. Identify, program, and specify custodial contracts required for base facilities and ensure contractor compliance with the contractual requirements.

5. Other Non-facility Requirements
   A. Provide professional architectural and engineering assistance to operations branch and to other organizations as required [3:82,83].

A review of these goals confirms a previous statement that goals in government organizations tend to be multiple, diverse, and vague. Thus, in setting objectives, the most difficult task is to define measurable objectives that truly represent the output or achievement of an individual manager and his organization.

The above goals must be stated in quantifiable terms as section objectives to be useful to the manager. One way objectives can be quantified is to identify quantifiable output and to state organizational objectives in terms of this output. In quantifying their output, managers must be careful to count those things that measure the organizational goals. This is a most difficult task in the design section as output ranges from such quantifiable items as project drawings, specifications, and cost estimates to such qualitative items as consultant services, customer satisfaction, and applicability of designs to construction codes and user requirements. Since this section's output is so diverse, it is obvious that no one output measure would adequately quantify all the work accomplished by this section. For this reason, multiple measures must be developed to adequately measure the productivity of this section.

PRODUCTIVITY AND OUTPUT MEASURES

General

Thus far, the nature of productivity in the federal government, the government emphasis on productivity, and the DOD Productivity Program have been discussed, but how does this justify the need to develop output measures? The discussion to follow on the relationship of productivity to output measures will answer this question.

Productivity has been previously defined as a ratio of output versus input with goals considered (i.e., goal directed efficiency). Thus, a productivity measurement is a ratio of measured output (i.e., units produced) to measured input (i.e., cost to produce those units) over a period of time where the output is directed toward achieving an organizational goal and the input is expended on producing that output. This definition of productivity measurement implies two important concepts. First, productivity is a "multivalued" concept. Second, productivity measurement is considered as a rate measurement.

Productivity is thus a combination of efficiency and effectiveness. An organization can be efficient without being productive. If the efficiency is not directed toward achieving an organizational goal, then the organization is not productive. The organization could be very efficient (maximum output/input) at producing A, but if B is our goal, then the organization is not productive. Likewise, an organization can be effective without being productive. If the organization is meeting its goals (effective) but is wasting resources (inefficient) in the process, then the organization is not productive. Therefore, any reference to productivity implies both efficiency and effectiveness.

A productivity measurement can be taken at any given point in time, but it has no meaning unless compared to some standard or trend. For example, one particular productivity measure may be defined as construction costs of a group of projects (output) divided by design costs (input). A measurement for one time period may result in a value of 10. What does the number 10 indicate? By itself, it indicates nothing, but when compared to a previous measurement from earlier time periods or to a target, it has some meaning. If previous measurements were 20 and 15, then 10 indicates that this productivity measure is getting worse. Thus, intangible goal achievement is best measured as a relative measure rather than an absolute measure.

These two previous examples point out the important aspects of productivity measurement. First, organizational goals must be defined. Second, output must be measurable (quantifiable). Third, inputs must be measurable (quantifiable). Fourth, a time period for the measurement must be specified. Within the design section of the BCE organization, goals have been identified (but not yet in quantitative terms), inputs are measurable, and a time period can be specified. The major missing piece of the puzzle is output measures. Thus, if output measures can be developed, the puzzle will be complete and productivity measures can be developed which will enable design section managers to measure productivity levels.

Definition of Terms

To eliminate conflicts which may arise from varying definitions and terminology used in the field, the following definitions, used for this research, are provided:

Input--the quantity of resources used by the organization during a specified period of time; resources consumed. Resources include personnel, costs, raw materials, facilities, budgets, supplies, and information. All inputs aggregated together must be of the same dimensional units.

Output--the quantity of goods, products, and services produced or provided during a specified period of time; results achieved.

Efficiency--the ratio of output to input; implies achieving results with minimal expenditure of resources; does not imply the appropriateness of the output to goal attainment.

Effectiveness--a measure of how well an organization is progressing towards its goals; achieving results at all costs or where cost is not a critical problem.

Goals--the strategic level organizational goals that relate the activities of a base level AFCE organization to its environment.

Objectives--the desired future conditions that are subgoals of the strategic level organizational goals which a base level AFCE organization branch wants to achieve through its activities.

Performance Indicator--the ratio of the actual to the desired output of a specific base level AFCE organization branch level activity in terms of quantity, quality, timeliness, and customer satisfaction.

Productivity--the measure of the effective and efficient use of resources to attain results which are directed towards achieving the strategic level organizational goals, through the branch level objectives. Productivity will be measured as a ratio of output to input.

BENEFITS OF PRODUCTIVITY MEASUREMENT

Productivity measurements are powerful tools for any manager. Even though these tools are more difficult to develop within military organizations because of substantive goals and policy constraints, some type of productivity measure is essential to assist management. The development of productivity measures will ultimately lead to better management in the areas of current operations and future operations (24:2-1).

In current operations, productivity measures will help management to objectively identify efficient operations, to identify and take effective, timely remedial action in potential trouble areas, to compare the relative production efficiency of similar functions performed on different bases, and to improve productivity and the methods and standards of operation (24:2-1).

As an aid in future planning, productivity measures will help managers to improve the planned allocation of resources; to improve the evaluation of effects of policy constraints by evaluating the feasibility (costs) of externally imposed constraints; and, to improve the integration of present policies with contingency requirements (24:2-2). By studying productivity measures, managers can more effectively test the feasibility and analyze the effect of various management policies. Since productivity measures can be used analytically, managers will be able to predict the advantages/disadvantages of both internal and external policy constraints on their organization's productivity. Productivity measures will indicate the potential effect of current manpower policies on the ability of the organization to meet its goals (projected workload).

Thus, the benefits of productivity measures are many. However, as previously stated, these measures cannot be developed without quantifiable output.

SUMMARY

Because of the nature of government organizations, productivity measurement is difficult. Goals tend to be multiple, diverse, and vague; output tends to be substantive and hard to quantify. The intense competition for available resources within the federal government has necessitated that DOD and its components become more productive. Recognizing this fact, DOD leaders have directed that a DOD Productivity Program be implemented. Before such a program can be implemented, productivity measures must be developed.

Productivity is a "multivalued" concept which includes both efficiency and effectiveness. A productivity measure has four parameters: defined organizational goals, measurable output, measurable input, and a time frame for these measurements and goals. Output measures have not been identified for the design section of the BCE organization. If output measures can be developed for this section, section managers will be able to measure productivity levels since the other three parameters presently exist.

Productivity measurement is important to managers because it will ultimately lead to better management in the areas of current and future operations. However, before these benefits can be realized, output and productivity measures must be developed.

Chapter 2

LITERATURE REVIEW

Before describing the research methodology designed to tackle the problem described in the previous chapter, a review of pertinent literature is required to familiarize the reader with previous studies associated with productivity measurement and their applicability to the development of productivity measures for the design section of a base level AFCE organization. This literature review will lead to the formalization of the problem statement for this research and will summarize the pertinent information that is needed to understand the contribution of this research to the current body of knowledge concerning productivity measurement in the AFCE organization.

DOD PRODUCTIVITY PROGRAM

The Department of Defense issued DOD Directive 5010.31, "Productivity Enhancement, Measurement and Evaluation—Policies and Responsibilities," on August 4, 1975. This directive established the DOD Productivity Program. In conjunction with this directive, DOD Instruction 5010.34, "Productivity Enhancement, Measurement, and Evaluation—Operating Guidelines and Reporting Instructions," was issued on the same date. This instruction applies to all Department of Defense agencies.

This instruction identified three goals for the head of each DOD component:

1. Establish annual productivity improvement goals (preferably by type of support function) for his Department/Agency.
2. Appropriately subdivide annual productivity improvement goals by major command and operating agency prior to the beginning of each fiscal year.
3. Advise the Secretary of Defense, by October 31 of each year, of the Department/Agency productivity improvement goals and the subdivisions thereof [43:2].

The instruction further stipulated that "each DOD component shall implement a Department/Agency-wide Productivity Program [43:2]." These programs were to contain the following minimum provisions:

1. Priority emphasis on productivity enhancement at all organizational levels.
2. Maximum use of existing resource management systems established under DOD Directive 7000.1, <u>Resource Management Systems of the Department of Defense</u>, dated August 22, 1966.
3. Development and appropriate use of productivity evaluation indicators [productivity measurements] which represent true measures of the primary workload or mission for each function included under the Productivity Program.
4. Accumulation of productivity data (units of goods produced or services rendered [output] and resources expended [input]) by major command and operating agency for each applicable function.
5. Utilization of productivity and performance data in the development of requirements and allocations of manpower and fund resources.
6. Adequate staffing and training of personnel to sustain a viable Productivity Program.
7. Periodic field reviews to assess program effectiveness [43:3].

To assist agencies in implementing this program, this DOD Instruction contains a section on productivity measurement and evaluation. Within this section, various organizational functions and suggested output indicators (measures) for the functions are listed. These output indicators are to be related to inputs to form a productivity index. This productivity index may be expressed as a dollar productivity index, a ratio of outputs to dollar resources expended, or as a labor productivity index, a ratio of outputs to labor resources expended. Note that this is consistent with the terminology used in this thesis.

A review of the list of functions and suggested output measures reveals that no measures are listed for the USAF civil engineering function. This further justifies the need for this research. Before civil engineering managers can implement a productivity program and comply with the minimum provisions of this DOD Directive, they must be able to measure output. Thus, this research will contribute to the implementation of the DOD Productivity Program within the civil engineering function (specifically, the design section) as specified in DOD Directive 5010.31.

BAUMGARTEL AND JOHNSON THESIS

A thesis accomplished at the Air Force Institute of Technology, School of Systems and Logistics, by the team of Baumgartel and Johnson (3) attempted to resolve this problem of productivity measurement within a base civil engineering organization. The objectives of their research were to: (1) develop strategic level organizational goals and branch level objectives of a BCE organization through synthesis of published Department of Defense (DOD) and Air Force policy directives and guidance; and (2) to determine if branch level activity output data in terms of quantity, quality, timeliness and customer satisfaction is currently recorded manually or through automated systems to establish performance indicators to complete a productivity measurement model for a base level USAF civil engineering organization (3:29).

This team conducted an extensive literature review of the many aspects of productivity and the various methods of productivity measurement.[1] Based upon their literature review, they concluded that the most appropriate method for measuring productivity in an AFCE organization was by a series of output-input measurements that are goal oriented. The output should be an indicator of performance and the input should be an indicator of the total resources required to obtain the performance level. Also, the measurement method should interface with the existing management information system (BEAMS), to avoid additional administrative work (3:22). These conclusions were reached by noting that

[1]If the reader desires a more extensive review of productivity and its measurement, we suggest that the reader examine the Baumgartel and Johnson thesis (see Bibliography).

AFCE managers often attempt to evaluate their mission accomplishment by relying on a variety of output and input indicators (i.e., existing management information systems, status charts, and commander's update briefings). Output to input comparisons are sometimes available, but become obscured in the bulk of the indicators which deal only with inputs or outputs. A problem arises in that the output indicators generally center on branch or section activities rather than objectives.

To establish a link between the actual output and the objectives of the branch, Baumgartel and Johnson developed a productivity measurement model based upon a network of performance indicator/input ratios. The performance indicators are ratios of actual to desired outputs of specific civil engineering branch level activities in terms of quantity, quality, timeliness, and customer satisfaction. The inputs are total resources (in dollars) used to obtain the specific branch activities; input information is available directly from existing automated products from the Base Engineer Automated Management System (BEAMS), as outlined in AFM 171-200, and the Resource Management System automated products as outlined in AFM 178-6. The productivity for a branch would be equal to the sum of that branch's performance indicators for all of its objectives and goals, divided by the total input to the branch (expressed in dollars). Thus, productivity measurement would be accomplished at the organization and branch levels, and would not be applicable to individual worker productivity. These productivity measurements could be computed periodically and compared to previous period measurements to allow the AFCE manager to analyze for trends.

Thus, the productivity measurement model focuses on outputs in terms of performance realized from a given level of resources consumed. The model is structured around a framework of strategic level organizational goals and the supporting branch level objectives and a number of output measures (performance indicators) which relate to the attainment of the goals. Also, the model focuses on strategic level organizational goals, not on: (1) internal organizational goals, such as training, work, safety, and inventory control; (2) individual participant goals; (3) external users' goals; or (4) base command goals. After a thorough review of published DOD and USAF policy directives and guidance, Baumgartel and Johnson listed the objectives of each branch of civil engineering. The list of objectives they identified for the design section was previously stated in this thesis.

Once the strategic level organizational goals and supporting branch objectives were developed, performance indicators relating to each objective were developed. The only quantitative performance indicators developed for the design section were the following:

1. Average Pavement Index/Desired Average

2. Percent Work Orders in Work Stoppage/Percent Desired

3. Number of Facility Inspections/Scheduled Inspections

4. Number of Projects Completed Per Period/Average Number

5. Percent Facilities with Custodial Contracts/ Percent Authorized

6. Average Work Order Review Time/Desired Review Time

A review of the design section's objectives reveals that this list is not complete.

Recognizing this inadequacy, Baumgartel and Johnson recommended that further research was needed to develop "additional output measurement data for branch level activities, that support the branch activities, and will be used for evaluating the results of the civil engineering squadron performance [3:110]." These additional output measures must be designed to provide the AFCE manager a tool with which to validly judge productivity within the organization.

It is apparent that the productivity measurement model presented by Baumgartel and Johnson has two major weaknesses: (1) the model has not been field tested, and (2) the list of output measures for the individual branch activities are inadequate.

OTHER RESEARCH

Department of the Navy Productivity Measurement Model

In 1969, Mellonics Systems Development Division (MSDD) of Litton Systems, Inc., under contract with the Department of the Navy, developed a productivity measurement model (24). Obviously, a productivity measurement model designed for the Navy would not be directly applicable to an Air Force Civil Engineering organization, but in its development, the researchers point out some important aspects of productivity measurement and modeling. Before developing the model, MSDD described the characteristics of an ideal model. The ideal productivity measurement model should have the following characteristics:

> 1. Should give an all-inclusive and totally objective measurement of the efficiency with which limited resources are being used to achieve an overall objective.
> 2. Should reflect all factors influencing productivity including tangible factors (such as labor, equipment, and facilities), all intangible factors (such as personnel morale and motivation), and all policy constraint factors such as manning level limits.
> 3. In the ideal model, one productivity index can be meaningfully compared with any other index and indices of subordinate units can be combined to give a meaningful index of the productivity of the superior unit as a whole.
> 4. Productivity indices can be meaningfully compared over time [24:3-1].

The researchers further point out that this ideal model would be extremely complex (if it could be devised at all), prohibitively expensive to run, and if the ideal were achieved, many managers could be replaced by computers (24:3-1).

The following definitions were used in the MSDD research:

1. Productivity Measurement: Basically, the ratio of outputs to inputs.

2. Productivity Index: The productivity measurement compared to a standard.

The accuracy and meaningfulness of the productivity measurement depends on the accuracy of the measurement of the inputs and the outputs, and on the appropriateness of the selected measurement units. The validity of the productivity index depends on the validity and compatibility of the standard, as well as on the accuracy of the productivity measurement. Thus, the problems associated with developing a productivity measurement model include problems of measurement of inputs and outputs, development of standards, and aggregation to higher levels (24:3-2).

The problems of measuring inputs are relatively minor. The only significant questions that have to be answered are whether all labor, equipment, and material are correctly allocated to the organization that used it and whether the various types of input are combined properly.

The problems associated with measuring outputs are more numerous and difficult than those associated with inputs. Government organizations normally produce a variety of outputs and the outputs are often intangible and difficult to measure. Some organizations have functions and outputs such that there is no feasible method of forming a meaningful productivity measure in its conventional sense (output/input). These outputs are of three classes:

1. Outputs of activities that are intangible and cannot be measured.

2. Output that varies inversely with the level of activity.

3. Output from an activity that functions only in an emergency.

In these cases, the productivity measures do not measure productivity; nevertheless, the ratios formed can be useful to the manager in indicating if an activity is overstaffed or understaffed (24:5-10).

The research also points out that there is a problem with summing the outputs of organizations into a single measure unless the outputs are compatible. For example, summing project drawings, specifications, and cost estimates into one output measure called number of project documents automatically sets the three equal in importance relative to each other. This would obviously be an erroneous assumption.

Based on the above discussion, we concluded that this research should not attempt to sum various output/input measures into a combined productivity measure for the entire design section as recommended by Baumgartel and Johnson. We also believe that the outputs of the design section do not wholly fit into one of the three categories of output which result in an infeasible productivity measure. For this reason, output measures and productivity measures can be developed for particular goals of the design section.

Alternate Productivity Measurement Model

A thesis by Hanley and Smith (17) proposed a different productivity measurement method than that proposed by Baumgartel and Johnson. They proposed that productivity can be measured as the ratio of manhours estimated to actual labor manhours expended. Using the terminology from the earlier model, this would define manhours estimated for a particular job as output and actual labor manhours expended as the input. The validity of this model is dependent upon the validity of the methodology for measuring productivity. Hanley and Smith pointed out that it is possible to obtain unsatisfactory productivity ratios as a result of:

1. Inaccurate labor manhour requirements estimating.
2. Production inefficiencies within the labor force.
3. Inaccuracies in labor data collection/processing.
4. A combination of the above.

They proposed that the most meaningful progress toward realizing increases in AFCE in-house work force productivity could result from analyses of inaccurate labor man-hour requirements estimating (17:4,5).

The greatest advantage of this productivity measurement method proposed by Hanley and Smith is that it could be applied to organizations whose outputs from activities are intangible or nonquantifiable. As the Navy productivity model (24) pointed out, the conventional productivity measure (a ratio of actual output to input) could not be applied to this class of outputs. It appears that the Hanley and Smith measure would be very useful within the design section of a base civil engineering organization since some of the output of this section is more qualitative than quantitative in nature.

A thesis by Moss and Meister (25) pointed out that approximately 40 percent of a design engineer's time is spent in facilities project design. Project design was defined to include: (1) review of programming documents; (2) review of record drawings; (3) necessary site visits to verify actual conditions; (4) meetings with using agencies to ensure that their functional requirements are met; (5) necessary research to ensure that Air Force regulations are complied with; (6) development of the project drawings and specifications; (7) required final coordination and approval procedures; and (8) compliance with any MAJCOM/USAF project review comments (25:5).

By developing a model for estimating the required design time based on the above listed variables, they felt an appropriate standard for the accuracy of estimated project design time could be developed. Thus, if the model were developed, it could contribute significantly to developing productivity measurements for the design section using the method proposed by Hanley and Smith (a ratio of estimated manhours to actual manhours). However, Moss and Meister were unable to develop a model because of the diversity of the variables involved. In the course of their analysis, they discovered that most bases were achieving between 20 and 40 percent accuracy in their manhour estimates for project design.

Since a model to accurately estimate design manhours has not been developed, and since the present accuracy achieved in these estimates is low, the alternate method of measuring productivity was deemed inappropriate at this time for application within the design section.

SUMMARY

The conventional method of measuring productivity is a ratio of quantifiable output and input with organizational goals/objectives considered. The reason this conventional method has not been applied to the design section of a BCE organization is the present insufficiency of output measures. More and better output measures need to be developed if conventional productivity measures are to be applied to this section. An alternate method of measuring productivity is as a ratio of estimated manhours to actual manhours expended towards achieving some objective. The validity of this method is dependent on the accuracy of the manhour estimates. For this reason, the alternate methods cannot be applied to the design section.

PROBLEM STATEMENT

Given the limited total resources available to U. S. Air Force Civil Engineering (AFCE), a means of systematically measuring and reporting productivity levels and trends is needed by base level civil engineering (BCE) managers to compare and evaluate relative efficiency and as an aid in allocating resources to the best advantage. Several productivity measurement models have been developed within the Department of Defense, but none have been operationalized within AFCE. The primary reason for this is the failure to operationally define meaningful productivity measurements within certain branches of the BCE organization. To adequately measure the productivity of an organization, both the input (resources consumed) and the output (performance achieved) must be measurable. Within the BCE organization, adequate input measures are well documented, but output measures are not as easily identified and documented. This is particularly true within the design section of the

BCE's Engineering and Environmental Planning Branch (DEEP). The output of this section is generally service oriented; and in some cases, not easily inventoried or intangible. The results of this output are often delayed and long range. Since adequate output measures have not been developed and used, the managers of the design section have been unable to develop meaningful productivity measures. Therefore, if output measures are identified, they can be combined with existing input measures (labor cost or manhours), which are currently documented, to formulate productivity measures (a ratio of output to input). Once formulated, these productivity measures should be validated in the field by those who must manage the design section. If valid productivity measures are developed and used, the managers of the design section will be able to detect trends of productivity and to allocate their available resources to the best advantage.

RESEARCH OBJECTIVES

The objectives of this research are (1) to develop specific output measures which relate to organizational goals and objectives for the design section of a base level (USAF) civil engineering organization; (2) develop productivity measures based on these output measures and input measures currently documented by the design section; and (3) validate the selected productivity measures in the field to determine if they will adequately assist the manager in accomplishing section objectives.

RESEARCH QUESTIONS

To accomplish the research objectives, the following research questions must be answered:

1. What output measures are appropriate to measure progress towards operational objectives of the design section of a base level Air Force Civil Engineering organization?

2. What productivity measures can be developed from these output measures using currently documented inputs?

3. Are the selected productivity measures considered valid by those who will use them?

Chapter 3

METHODOLOGY

OVERVIEW

As part of this research project, a study was designed to identify productivity measures for the AFCE manager of the base level AFCE design section. This study consisted of the development of output measures, productivity (a ratio of output to input) measures, and an associated questionnaire to survey AFCE managers' attitudes on these measures.

DEVELOPMENT OF OUTPUT AND PRODUCTIVITY MEASURES

Based on the literature review, we decided the most appropriate method for measuring the productivity of the design section was by use of a series of output-input measurements that are goal oriented. Because of the diversity of objectives, the measures should not be aggregated into a single productivity measure, but rather should be compiled separately to indicate performance in one particular aspect of the organization function. For this reason, measures should be developed for each of the organizational objectives. The output should be an indicator of performance and the input should be an indicator of the resources required to obtain the performance level. Also, the measures developed should interface with the existing management information systems and should be derived from information currently compiled or recorded in AFCE organizations to avoid additional administrative work.

The evolution of output measures for this research began with a thorough review of existing literature for output measures currently compiled or recorded in AFCE organizations. The review included Air Force and Department of Defense (DOD) manuals, regulations, pamphlets, and instructions (1; 4; 11; 38-43); unpublished theses from the Air Force Institute of Technology (AFIT) and the Naval Postgraduate School (2; 3; 8; 17; 25); and numerous management periodicals, books, and textbooks (16; 18; 20; 26; 31; 33; 34).

The Air Force Civil Engineering organization has an abundance of reports, briefing requirements, and a management information system that require the compilation and recording of output and input measures. The most prolific of these tools is the Base Engineer Automated Management System (BEAMS) report which has been described as probably the most comprehensive performance reporting system in use in the Air Force today (11:58). The output measures which resulted from this review of information were compiled and tabulated (see Appendix B) by listing the measures and their source.

Before these output measures could be combined with input measures to form a productivity measure, it was necessary to identify relevant input measures which were currently compiled. The only quantifiable inputs available in the existing system were direct labor cost and manhours. Thus, the productivity measures developed could deal only with labor inputs. The development of more comprehensive productivity measures could include some other measurable factors which are currently not compiled. For example, the amount of equipment available is an important factor in the productivity of the labor used. Likewise, the facilities used by the organization should be considered to enable managers to analyze how facilities affect their productivity. For this research, we assumed that the differences in equipment and facilities available to the various design sections were not significant since all sections are controlled by the same organizational structure. Similarly, it was assumed that the amount of materials used did not significantly affect the labor productivity. The overhead cost for all sections was assumed to be equivalent and thus would not affect the productivity measure. For the above reasons, labor inputs were the only input measures included in formulating the productivity measures.

The formulation of the productivity measures (ratios of output to input relating to section objectives) was a culmination of (1) identifying the objectives of the design section (from Baumgartel and Johnson thesis), (2) a review of available information to select currently compiled and relevant output and input measures, and (3) personal experience of the researchers (a total of 12 years at different levels of the Civil Engineering organization).

POPULATION

With productivity measures identified, refinement of the measures and development of a survey instrument were the next taskings in the research process. However, before the survey instrument was developed, it was first necessary to consider the population from which the data would be gathered. The population for this research was all base level AFCE managers who would monitor and/or control the productivity of the design section in a base level civil engineering organization (i.e., the Base Civil Engineer, the Industrial Engineer, and the Chief of Design). This included both USAF military personnel and DOD civilian employees. The sample used in this research was all 82 base civil engineering organizations in the continental United States (CONUS) (see Appendix C, Part II); these are listed in AFM 10-1, Air Force Directory of Unclassified Addresses. The sample was chosen to garner the opinions of those directly involved in the day-to-day management of a base AFCE organization. The choice of only CONUS locations was also purposeful because of the after-survey accessibility that might be required following an analysis of the survey results and the perceived ease (time constraint) of data collection. Although the sample was restricted to bases in the CONUS, the results can be utilized by the overseas bases due to the similar framework of AFCE organizations worldwide and the existence of basic manuals and regulations that guide the AFCE operation.

INSTRUMENT - THE QUESTIONNAIRE

General

After the productivity measures were identified and the population defined, a survey instrument for the collection of data had to be selected. Since a major premise in this research was that the development of management tools (such as productivity measures) should include or at least consider the opinions of those who must use them, it followed that the AFCE managers in the field must be queried before any measures could be considered valid. The two basic methods of gathering such data are the mailed questionnaire and the telephonic or personal interview. Because of the size of the population (238 persons) and the geographical dispersion of the respondents, the mailed questionnaire was considered to be the most reasonable survey instrument for data collection. It has the appeal of gathering a large volume of data in a relatively short period of time and at a lower cost than the personal or telephonic interview. The questionnaire also has the advantages of increasing the likelihood that a respondent will divulge more information of a personal nature (more so than in a personal interview) and decreasing personal bias regarding incorrectly recording the information by an interviewer (5:77,78).

Many advantages of the questionnaire existed but there were also several disadvantages considered. First, the degree to which the survey purports to represent reality is difficult to determine. This is basically a result of the relatively large percentage of mailed questionnaires that are not returned. This problem of nonresponse is closely tied to data validity which will be discussed later. Second, some questions may be omitted or incorrectly answered because they were misunderstood and no one was present to clarify the ambiguity. The result is a possible loss of valuable information that could be used to develop a better picture of what the researchers propose to explain. Despite these considerations, the advantages were felt to far outweigh the disadvantages; hence the decision to use the questionnaire.

Design of the Questionnaire

Structure. The questionnaire was divided into three parts: individual information, general organization information, and a productivity section. A complete copy of the questionnaire appears in Appendix C, Part I.

Part I: Individual Information (questions 1-5) was concerned with gathering descriptive data about the individual respondents (i.e., grade/rank, position, experience, and education level). This information was used to classify the respondents and to determine if the attitudes of the respondents toward particular productivity measures varied according to the classification. This point will be discussed later in the data analysis section.

Part II: General Organization Information (questions 6-9) was used to gather descriptive data concerning the organization within which each respondent worked, such as major command, geographical location of the base, size of the design section, and whether or not the Base Engineer Automated Management System (BEAMS) was being used at the base.

Part III: The Productivity portion contained statements designed to garner the attitudes of the respondents towards selected productivity measures in terms of their usefulness to the base level civil engineering organization. Within this section, the respondents' perceptions of the need for productivity measures and the need for a formal program are addressed (questions 10 and 12) as well as the respondents' attitudes towards the appropriateness of specific measures for the BCE design section (question 11, parts a through ll). Finally, an open-ended question was included to allow the respondents to identify additional productivity measures that he or she has used or feel could be used in the BCE design section and to express any opinions about productivity and its measurement in the base level AFCE organization.

Questions within these three sections (Parts I, II, & III) were then formatted so that they could be easily answered and would require minimal time for the particular managers being surveyed. Brevity, simplicity, and response forms are some factors which were considered to make the questionnaire mechanically easier to answer and to improve the chances that more managers would take the time to answer it. However, it was not the intent of the researchers to sacrifice the quality of the data to be collected by reducing the time each respondent would take in answering the questionnaire. Thus, question wording and content were among the factors that were considered in this aspect of the questionnaire structure.

<u>Validity of the survey instrument</u>. The final tasking in the design of the questionnaire was to determine if it was valid.

Validity is the degree that the differences found through the survey equate to the actual differences among those surveyed. A dilemma existed in that the researchers did not know what the actual differences were (no standards exist) and, if the actual difference were known, there would be no reason to be measuring. In the absence of actual standards, one approach to validity is to determine if the contents of the instrument are representative of the subject matter (9:120). Thus, our approach was to provide the draft questionnaire to a panel of graduate students from the Air Force Institute of Technology, School of Systems and Logistics, for an initial check of the proposed measures. Each of the students had at least five years of prior experience in the AFCE career field, had been assigned to or managed a base level BCE design section, and had recently been acknowledged for outstanding performance in an AFCE organization (see Appendix A, Part I). Recommendations were discussed with each of the respondents and the questionnaire was either changed or remained intact based on unanimity of researchers and the respondent. The revised questionnaire was then presented to faculty members of the AFIT School of Civil Engineering staff (see Appendix A, Part II). Again, recommendations were discussed with the researchers and changes made accordingly.

The Measurement Scale

As previously stated, the purpose of the questionnaire was to gather information reflecting the attitudes of base level AFCE managers toward a number of productivity measures. However, the evaluation of this information required a means to measure the attitudes of the respondents. This measurement (quantification) was accomplished by scaling each question. Scaling is a "procedure for the assignment of numbers (or other symbols) to a property of objects in order to impart some characteristics of numbers to the properties in question [29:205]." There are generally four types of scales and they are briefly summarized below:

Nominal - naming scales that only specify membership in a category.

Ordinal - scales that specify a quantitative relation among different categories (or points) of the scale; limited to statements of equivalence and inequality.

Interval - formed when the distances between any two points are known for all values on the scale.

Ratio - one which has an absolute zero point as well as the characteristics of an interval scale.

Since attitudes are real-life phenomena, they usually require nominal or ordinal scaling (10:123). Two types of scales commonly used to measure attitudes are the Likert Scale and the Thurstone Differential Scale.

With the Likert scale, the respondent is asked to respond to statements in terms of 5 degrees of agreement (3- and 7-point scales can also be used). An example of the response format is shown below:

I like my job.

☐	☐	☐	☐	☐
Strongly Agree (1)	Agree (2)	Undecided (3)	Disagree (4)	Strongly Disagree (5)

Each of the alternatives (strongly agree, agree, etc.) are assigned a numerical value (as shown above) and a total score is obtained for each item. Thus, the Likert scale uses an ordinal level of measurement and applies a numerical score to reflect a favorable or unfavorable attitude toward an item of interest.

The Thurstone Differential Scale was an effort to develop an interval scaling method for attitude measurement. The differential scale is developed by asking a large number of judges (often 50 or more) to evaluate statements which are presented on cards. The judges are asked to sort each card into one of eleven piles based on the degree of favorableness that the statement expresses. The scale position for a given statement is determined by calculating its median score when placement in the least favorable pile is scored as "1", and most favorable pile as "11". A measure of dispersion is calculated for each statement, usually the interquartile range. If the interquartile range is large for a given statement, that statement is discarded as being too ambiguous. The selection of statements to be included in the final attitude scale is made by taking a sample of statements whose median scores are spread evenly from one extreme to the other, and whose interquartile range is small (9:246).

It can be seen from the above discussion that the Thurstone Differential Scale is applicable only when statements represent different degrees of favorableness toward one particular object or dimension being measured. Since the questionnaire used in this research was designed to garner the attitudes of the respondents towards a number of specific productivity measures (objects), the Thurstone Differential Scale was inapplicable to this research. This fact presented a problem to the researchers in that parametric tests were to be applied to the data and such tests require an interval scaling method.

As pointed out earlier, a significant disadvantage of the Likert Scale is that it is an ordinal scaling method. However, researchers recognize the difficulty in assessing absolute levels of measure when dealing with attitudes. As Gardner points out (13:55-56):

1. The distinction between ordinal and interval scales is not sharp. Many summated scales (such as the Likert Scale) yield scores that, although not strictly of interval strength, are only mildly distorted versions of an interval scale.

2. Some of the arguments underlying the assertion that parametric procedures require interval strength statistics appear to be of doubtful validity.

3. Parametric procedures are, in any case, robust and yield valid conclusions, even when mildly distorted data are fed into them. Furthermore, if the distortions are severe, various transformation techniques can be applied to the data.

Research has shown that Likert's scale method of attitude measurement yields almost identical results with Thurstone's method and is perhaps the most satisfactory technique now available for attitude measurement. Some reasons are (35:153,154):

1. It avoids the difficulties encountered when using a judging group to construct the scale (as with Thurstone's technique).

2. It yields reliabilities as high as those obtained by other techniques, with fewer items.

3. It is possible to obtain the most typical measure of an individual's attitude and also the range of dispersion of his attitude.

4. The construction of an attitude scale by Likert's method is much quicker and easier than by using a judging group and does not involve any of the errors likely to be present in any technique in which experts, judges, or raters are used.

For the above reasons, Likert's method of attitude measurement was selected. The researchers assumed that use of Likert's scale would result in only "mildly distorted" interval level data and, therefore, the use of parametric statistical techniques is justified. In addition, we chose a 7-point Likert Scale to reduce the possibility of ties between measures and for its better discriminating ability.

Conducting the Survey

AFM 10-1, Air Force Directory of Unclassified Addresses, provided the list of addresses required to reach the target population (see Appendix C, Part II). There were 238 respondents identified by position (the Base Civil Engineer, Industrial Engineer, and the Chief of Design) for 82 CONUS bases. Each respondent was sent a survey package that included a questionnaire and a preaddressed return envelope. In addition, each survey package contained instructions for completing the questionnaire, a statement of purpose, and a copy of the Privacy Statement required by the Privacy Act of 1974. The questionnaires were mailed on 5 March 1980 with a completion deadline of 25 March 1980.

DATA PREPARATION

The previous sections were concerned with developing a data collection plan. Also of importance in developing a research methodology was a plan for data analysis. The definition of analysis used in this research was the breaking down and ordering of data into meaningful groups, plus the searching for patterns of relationships among these data groups (9:337). The first step in the analysis was data preparation which includes editing and coding.

Editing

Once the data was collected, it was first necessary to edit the raw data. The purpose of this editing process was to ensure that the data was (9:337): (1) as accurate as possible; (2) consistent with other facts secured; (3) uniformly entered; (4) as complete as possible; (5) acceptable for tabulation; and (6) arranged to facilitate coding and analysis. During this editing process, all incomplete and miscoded questionnaires were discarded and not included in further analysis.

Coding

The second analysis method was coding the answers received from the respondents of the survey. The coding process consisted of assigning numerals or other symbols to answers so as to enable the responses to be grouped into a limited number of classes (9:339). Coding of data into a limited number of categories sacrificed some of the data detail but was necessary for efficient tabulation and analysis by using the computer. In this categorization process, four rules were applied. Categories should be (9:339):

1. Appropriate to the research problem and purpose.
2. Exhaustive.
3. Mutually exclusive.
4. Derived from one classification principle.

Most of the data received was already categorized as a result of question formatting (see Appendix E). However, the answers to question 4 required the use of categories. This categorization was based on the typical career progression of an AFCE officer. Category 1 individuals would have just entered the CE career field and would be in the process of learning their job. Category 2 individuals were assumed to have specific knowledge of at least one position in the organization and general knowledge of the functioning of other positions (branches). Category 3 persons were assumed to have specific knowledge of several positions (and branches) and some middle management experience. Category 4 individuals were assumed to have specific knowledge of the overall functioning of the BCE organization and considerable middle and upper level management experience. This categorization follows the four rules previously stated.

Usefulness Index

In Part III of the questionnaire, respondents were asked to identify their degree of agreement (or disagreement) with specific productivity measures in terms of their usefulness to the managers of the design section. In order to determine which measures were considered useful and which were not, a usefulness scale was developed. Since the respondents were asked to indicate their attitude on a 7-point Likert Scale, a similar scale was chosen for this purpose. Figure 1 shows the scale by which the productivity measures were evaluated.

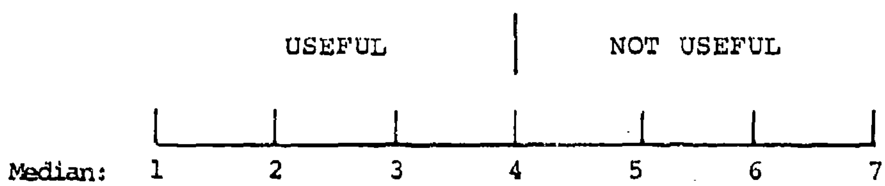

Fig. 1. Usefulness Scale

As indicated above, a median of four (4) was used as the separation point between useful and not useful. The median was selected as the descriptor rather than the mean since the distribution of responses to the various productivity measures was seldom symmetrical. In such cases, the mean tends to be located somewhat away from the concentration of items and yield a distorted picture of the position of usefulness attributed to the measure. Also, since the respondents were asked to answer in discrete categories and the mean is a continuous descriptor, the median was selected. Additionally, the median is less influenced by extremes in position than is the mean; thus, the median yields a less distorted picture of the position held by most respondents. Therefore, if the median value approached the "1" end of the scale, we assumed this to indicate an increasing perceived usefulness; conversely, as the value approached the "7" end, this indicated a decreasing usefulness.

With this usefulness index identified, we were able to select those productivity measures which the respondents perceived would be useful to the management of the design section.

Descriptive Statistics

The results of the first computer run using the SPSS Subprogram FREQUENCIES were compiled into a table (see Appendix F). This table included the measure, the median, the mean, and the standard deviation of the responses. All measures with a usefulness index of less than 4.00 were then tabulated in a separate table (see Chapter 4) as a summary of those productivity measures perceived by the respondents as being useful for the management of the design section.

Content Validity

Once this initial analysis was accomplished, the researchers were concerned that the results of the analysis be representative of the population sampled. If the results do not represent the true attitudes of the respondents, there can be no expansion of knowledge and no meaning to the analysis results. For this reason, content validity had to be established.

A problem immediately arose in that there is no single statistical criterion which can be used to determine whether or not one has properly sampled from the population under investigation (35:92). In addition, for this research there were no acceptable standards against which to compare the selected productivity measures. To offset these handicaps, we evaluated content validity based on the assumptions that (1) demographic data could be used to evaluate consistency of results, (2) randomly splitting the sample would assist in determining internal consistency, and (3) common sense could be used to determine content validity (28:486-494).

Crosstabbing with demographic data. As mentioned earlier, a demographic section was incorporated into the questionnaire. By crosstabbing position (BCE, Industrial Engineer, or Chief of Design), military/civilian status, and experience level (years in an AFCE organization) with manager attitudes toward each measure, a check for the consistency of results could be made. Those measures which were consistently selected as being useful regardless of the characteristics of the respondents would be considered the most valid. This crosstabbing procedure also permitted the evaluation of differences in attitudes among various categories of respondents. The SPSS Subprogram CROSSTABS was used for this crosstabbing procedure. Three computer programs were run: the first crosstabbed position by attitudes toward each measure; the second, military versus civilian status by attitudes; and the third, experience by attitudes. The results of these programs are summarized in Table 6 of Chapter 4. Also, a typical CROSSTABS program is listed in Appendix D. Of the three categories, experience was considered to be the most important indicator of respondents who were experts or persons qualified to know the true situation. The most useful measures were assumed to be those selected by the most experienced managers (ten or more years experience) since they would have a better understanding of the functioning of the design section.

Random splitting. The second approach to content validity centered on the realization that there were no standards of productivity currently used in AFCE units against which to compare our data. Therefore, we utilized a statistical technique of randomly splitting the collected data into smaller subsamples (we arbitrarily used 50 percent) and compared these smaller samples to the original sample to detect if major variances existed within the data. If none existed, we could more conclusively analyze and make inferences about the population knowing a fair degree of uniformity existed within the larger sample of the population. Three random splits were made on the data and descriptive statistics were calculated (this was all accomplished by the computer). The results of these random splits were included in Table 6 of Chapter 4.

Common sense. The final approach to content validity was to assume that common sense was a test of validity. In view of the fact that systematic questionnaire studies are undertaken because we do not trust the common sense estimates, we hardly use the latter as the sole criteria for the validity of the former. But, in the absence of standards or norms, and always in addition to them, common sense is entitled to consideration (28:494).

The Open-End Question

As previously mentioned, an open-end question was included in Part III of the questionnaire. This question was informally analyzed by the researchers using content analysis. A summarized listing of comments is included in Appendix H and the results of the content analysis are discussed in Chapter 4.

Chapter 4

FINDINGS AND ANALYSIS

This chapter presents an analysis of the data collected in this research effort and answers the research questions posed in Chapter 2 of this study. The chapter begins with the research findings of output measures, followed by a presentation of the data, and, finally, an analysis of the findings.

OUTPUT MEASURES

The Base Civil Engineering (BCE) organization has an important and complex mission as any other organization on an air base. First, the BCE manages or otherwise administers some 40 to 60 percent of most installations' Operations and Maintenance (O&M) budget; second, the BCE probably has the largest number of general and special purpose vehicles along with the largest work force; finally, the BCE, or the work that is performed by the BCE, receives more daily visibility than any other organization. Such an organization has many output measures that are recorded, tabulated, and often analyzed for trends. In all, there were 26 output measures (see Appendix B) considered for the BCE design section at various states of this study. Through an iterative and discriminating process (see Chapter 3 for details), a final list of 19 output measures was selected for incorporation into the research questionnaire as the numerators in the productivity measures (see Appendix C, Part I).

QUESTIONNAIRE RESPONSE

There were 238 surveys mailed to 82 Air Force installations within the CONUS. The response rate was 59.7 percent with the return of 141 surveys; however, 12 of the returned surveys were not used in the analysis that followed because the respondents had either incorrectly or only partially completed the questionnaire. Thus, all analyses of data were based on the remaining 129 returned surveys (54.2 percent of the original number mailed). Table 1 illustrates a more complete breakdown of the respondents.

Table 1

Response Breakout by Position

Position	Mailed	Returned	Percent Returned
Base Civil Engineer	82	31	37.8
Chief, Design Section	78	58	74.4
Chief, Industrial Engineer	78	39	50.0
Other	0	1	----
	238	129	54.2

CHARACTERISTICS OF THE SAMPLE

The sample of 129 respondents provided data from a wide range of backgrounds. By rank, respondents held military ranks from colonel to second lieutenant and civilian grades of GS-13 through GS-9. This rank and grade spread is shown in Table 2 below.

Table 2

Rank/Grade of Respondents by Position

Grade	Base Civil Engineer	Chief of Design	Chief of IE	Other	Total
Colonel	7	0	0	0	7
Lt Col	13	0	2	0	15
Major	2	3	1	0	6
Captain	1	9	6	0	16
1Lt	0	0	3	0	3
2LT	0	4	9	0	13
GS-13	8	19	1	0	28
GS-12	0	21	4	0	25
GS-11	0	2	11	0	13
GS-10	0	0	0	0	0
GS-9	0	0	2	1	3
	31	58	39	1	129

The experience levels of the respondents also exhibited a high degree of variability in that the respondents' cumulative time in any AFCE organization ranged from just a few months to over 30 years of federal service. This trait is depicted in Figure 2.

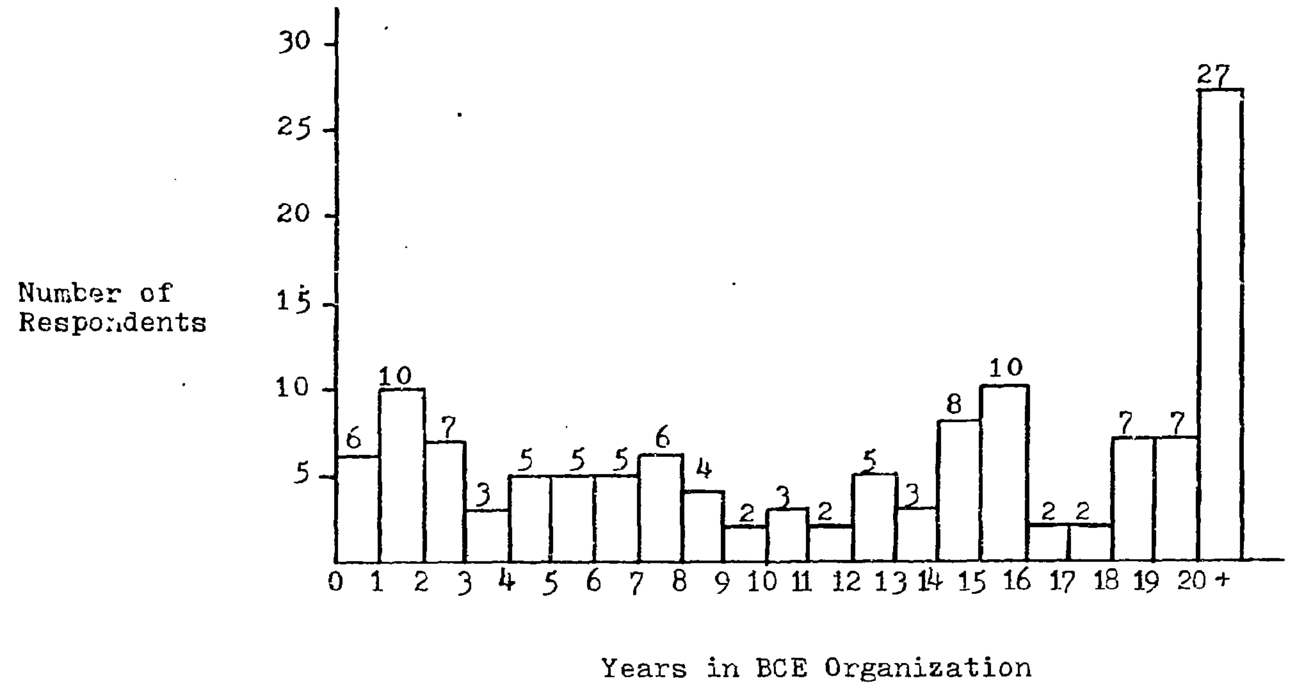

Fig. 2. Experience (Cumulative Time in any BCE Organization)

Education-wise, the sample of 129 respondents demonstrated a fairly high level of formal education. More than 93 percent of the respondents had at least a bachelor's degree and over half had graduate degrees or some graduate course work to their credit (including one with a doctorate). Figure 3 provides a complete breakdown by the respondents' education levels.

Finally, the respondents provided data from an assortment of geographic regions around the continental United States (CONUS). The names of the installations were not requested to protect the anonymity of the respondents but major command (MAJCOM) identities were requested and Table 3 provides this information.

Table 3

Number of Respondents by MAJCOM

MAJCOM	Number of Surveys Sent	Number Responding	Response Rate (%)
ADC	5	0	0
AFLC	15	8	53.4
AFSC	12	6	50.0
ATC	31	20	64.5
MAC	39	16	41.2
SAC	75	42	56.0
SOA	3	2	66.7
TAC	58	35	60.3
	238	129	

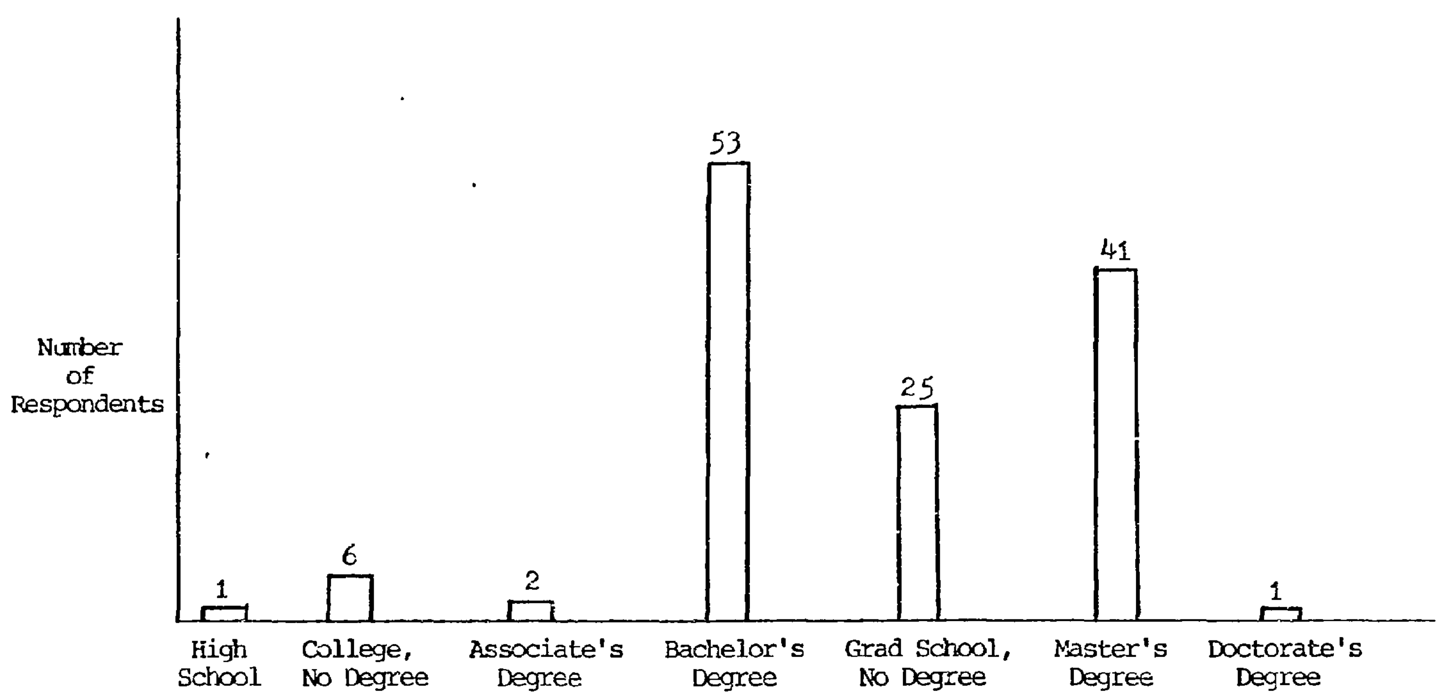

Fig. 3. Education Level

ANALYSIS OF PRODUCTIVITY MEASURES

There were two major concerns in the analysis of the responses to the productivity questions of the survey instrument. The first was to determine the general attitude of base level AFCE managers towards the need for productivity measures in the base AFCE organization; the second was to identify measures that would be most useful for the design section.

Entire Sample

The first computer run was conducted on all 129 respondents (see Appendix D for the Statistical Package for the Social Sciences (SPSS) Subprogram used). This run indicated that there was a definite agreement among base level AFCE managers that productivity measures were needed in the BCE organization (variable N9). In fact, 39 of the respondents had annotated the "strongly agree" block and another 39 the "agree" block. In all, nearly 75 percent of the sample agreed in some degree that measures were needed to detect productivity trends or to assist management; the median was 2.154 and the mode (the category chosen most often) was tied between the choices of "strongly agree" and "agree" with 39 responses apiece. Figure 4 and Table 4 provide additional graphics of the respondents' general support in this matter.

```
          PROD MEASURES NEEDED IN BCE
CODE
          I
     1.   *************************************** (      39)
          I   STRONGLY AGREE
          I
          I
     2.   *************************************** (      39)
          I   AGREE
          I
          I
     3.   ****************** (      18)
          I   SLIGHTLY AGREE
          I
          I
     4.   ****** (      6)
          I   UNDECIDED
          I
          I
     5.   ******* (      7)
          I   SLIGHTLY DISAGREE
          I
          I
     6.   ********** (      10)
          I   DISAGREE
          I
          I
     7.   ********** (      10)
          I   STRONGLY DISAGREE
          I
          I.........I.........I.........I.........I.........I
          0        10        20        30        40        50
```

FREQUENCY (Number of Respondents)

Median = 2.154

Fig. 4. Variable N9 Distribution Chart

Table 4

Frequencies Table for Question 10 (Variable N9)

Category Lable	Code	Absolute Frequency	Relative Frequency (%)	Cumulative Frequency (5)
Strongly Agree	1	39	30.2	30.2
Agree	2	39	30.2	60.4
Slightly Agree	3	18	14.0	74.4
Undecided	4	6	4.7	79.1
Slightly Disagree	5	7	5.3	84.4
Disagree	6	10	7.8	92.2
Strongly Disagree	7	10	7.8	100.0
	TOTAL	129	100.0	

Despite the definite positive attitude for the need of the productivity measures, the respondents had a less enthusiastic opinion for a formal productivity program for the BCE organization (variable N48). The sample was still slightly skewed to the "agree" end of the 7-point Likert scale with a median of 3.425 and with 51.2 percent of the respondents agreeing; however, the possibility of additional work requirements (in the form of collecting, analyzing, and reporting on the productivity measures) probably caused many respondents to answer towards the "disagree" end of the scale. There was also the indication based on some of the comments to the open-ended portion of the questionnaire (see Appendix H) that many preferred to tailor productivity measurement on their own and keep the information on a local level rather than having to work another controlled report.

The analysis of the entire sample of 129 respondents also identified six (6) productivity measures considered to be useful to managers of the BCE design section. Table 5 lists these measures. Other graphic information for each of the measures noted in Table 5 are included in Appendix G. It should be noted that the productivity measures designated by variables N10 and N29 utilized the same numerator (output) but different denominators (input); variables N16 and N35 also shared the same numerator but differed in the denominator. More than anything else, this occurrence seemed to indicate to the researchers that the output measures used to

Table 5

Useful Productivity Measures

Questionnaire Number	Variable Number	Description	(Likert Scale) Median
11a	N10	Total estimated dollar amount of contract projects and in-house work orders designed divided by total design manhours.	3.089
11g	N16	Total number of projects designed (complete and ready for acquisition action) divided by total design manhours.	3.229
11h	N17	Total number of facility inspections and utility systems surveys completed divided by total man-hours to complete surveys and inspections.	3.426
11o	N24	Total estimated dollar amount of architectural-engineer (A-E) design acquisition packages prepared divided by the total manhours to prepare.	3.636
11t	N29	Total estimated dollar amount of contract projects and in-house work orders designed divided by total design labor cost.	3.692
11z	N35	Total number of projects designed (complete and ready for acquisition action) divided by total design labor cost.	3.556

make up those productivity measures were extremely useful. This was based on the observations that the respondents generally disliked the labor cost input measure and that the counterparts to variables N17 and N24 did not show up as useful measures.

Partial Samples

As mentioned in the methodology (Chapter 3), the researchers were concerned that the results from an analysis of the sample be representative of the population. To offset the handicap that no standards or norms existed against which to compare the selected productivity measures, we evaluated the content validity of the sample based on cross-tabulations of the various measures against such demographic data as the respondents' positions, military versus civilian status, and experience levels; in addition to the cross-tabulations, the researchers also used the random splitting technique to assist in determining internal consistency. The results of these analyses are tabulated in Table 6.

By position. Thirty-one base civil engineers (DEs) responded to the questionnaire and their responses were fairly consistent with the results of the entire sample. In addition to the six useful productivity measures identified in the entire sample, the DEs considered another three measures to be useful to management of the design section (see Table 7).

Table 6

Summary of Partial Samples

Sample \ Variable #	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
Entire Sample (129)	x	x						x	x							x					x						x													x
By Position																																								
DEs (31)	x	x	x					x	x							x		x			x	x					x													x
DEEs (58)	x	x						x								x																								
IEs (39)	x	x						x	x	x		x		x	x	x		x	x	x	x						x	x	x		x				x					
Military (60)	x	x						x	x							x		x	x		x						x	x												x
Civilians (69)	x	x	x					x						x		x											x													x
By Experience Level																																								
0-.99 (13)	x	x						x	x	x						x		x	x	x	x	x				x	x	x	x	x		x			x				x	x
1.0-3.99 (16)	x	x	x	x	x	x		x	x					x	x	x		x	x	x	x	x	x	x	x		x	x					x	x	x	x	x	x	x	x
4.0-9.99 (25)	x	x												x		x																								
10+ (75)	x	x	x					x	x							x		x			x						x													x
Random Splitting																																								
50% (54)	x	x						x	x							x					x						x													x
50% (66)	x	x						x													x						x													x
50% (70)	x	x						x	x					x		x		x	x		x						x													x

"x" indic es a median less than 4.

Table 7

Additional Measures Preferred by Base Civil Engineers

Questionnaire Number	Variable Number	Description	Median
11b	N11	Total contract funds obligated (i.e., MCP, O&M, etc.) divided by total design man-hours associated with contract funds obligated.	3.625
11q	N26	Number of work orders evaluated and/or reviewed divided by total manhours required for review and/or evaluation.	3.800
11u	N30	Total contract funds obligated (i.e., MCP, O&M, etc.) divided by total design labor cost associated with contract funds obligated.	3.313

The responses from the chiefs of the design sections were the most restrictive in terms of the identification of useful productivity measures. Only three measures (designated by variables N10, N16, and N24) complied with having a median less than four but all three are ones that showed up in the entire sample. Finally, the analysis of the responses from the chiefs of the industrial engineering sections revealed a total of 17 measures considered to be useful for management; again, all six of the measures identified in the original sample of 129 respondents appeared in these identified by the industrial engineers.

Although the number of useful productivity measures differed from position to position, the researchers expected such a variety to exist. We expected the identification of some basic measures (i.e., the six useful measures noted in Table 5); however, since each position essentially represented a different managerial frame of reference in the BCE organization, we expected and the respondents did identify measures that were of most concern to them in their day-to-day activities.

By military versus civilian status. The analysis of the 60 military respondents revealed nine useful measures, including all six from the entire sample. Only six measures (four of which were identified in the entire sample) were found from the 69 civilian respondents. The researchers did not feel that either of these partial samples presented a significant departure from the total sample of 129 respondents.

By experience levels. Of all the partial samples, the cross-tabulation by experience levels was considered by the researchers to be the most important indicator of the true situation. In particular, the most useful measures were assumed to be those selected by the most experienced managers (ten or more years experience in any BCE organization) since they would theoretically have a better understanding of the functioning of the BCE organization and the design section. As such, the first three categories were only given a cursory review and the useful measures noted in Table 6; besides, each of these categories designating lesser experience levels represented less than 20 percent of the entire sample. The category depicting the most experienced managers contained 75 respondents and nearly replicated the findings of the entire sample. The only exceptions were the measures designated by variables N11 and N26 with medians of 3.600 and 3.917, respectively.

Random splitting. The researchers utilized the random splitting technique to detect if major variances existed in the data collected. Approximately 50 percent of the 129 respondents (hence the different sample sizes of the random splits) were randomly selected and analyzed by the computer. In each run, useful productivity measures were identified based on the previously stated criterion (median less than 4). There was a slight degree of variability in terms of the different measures considered to be useful, but, only those six measures identified in the sample of 129 respondents repeatedly surfaced.

Other considerations. Two measures, designated by variables N11 and N26 (see Table 7 for description), did not meet our main selection criterion for a useful productivity measure when analyzed within the entire sample of 129 respondents. The medians were 4.444 and 4.000, respectively; however, both measures conspicuously met our criterion in two prominent partial samples: the Base Civil Engineers and the most experienced AFCE managers (over ten years in a BCE organization). For this reason, both measures may be considered useful to the managers of the design section.

The Open-Ended Question

Although not rigorous in nature, the content analysis of the open-ended question portion provided some useful information with regard to productivity measurement in the design section. Also, it provided a measure of questionnaire validity since the open-ended question tended to reaffirm findings based on the attitudinal questions (questions 10-12). A summarization of the comments made by respondents to the open-ended question appears in Appendix H; the comments were categorized into eight categories. These categories provided the basis for the remaining discussion.

Category 1 was the most predominant with 23 responses. This category indicated that the managers in the field were concerned with comparing the productivity of individual engineers since they felt that variables internal to the design section such as the complexity of individual projects, the experience of engineers, and the engineering discipline needed to be considered in productivity measurement. It was not the intent of this research to develop measures which could be used to compare the productivity of individuals, but rather to develop measures which could be used by managers to detect trends in the productivity of the entire section. However, productivity measurement of individual engineers is an area which warrants further study based on the predominance of this comment.

Category 2 (20 responses) and category 5 (13 responses) comments indicated that the base level managers were also concerned with higher level managers using these measures to compare the productivity of different design sections. Based on the comments, it appeared that the base level managers preferred to keep the productivity measurement informal with no reporting to higher levels of command. Also, since each design section operated in a dynamic environment which, to some extent, cannot be controlled by managers of this section, comparing the productivity of two or more design sections using these measures was questionable, if not infeasible. However, if two design sections operated within similar environments (equivalent funding of projects, similar command interest and higher command directives), then comparisons could be both meaningful and useful.

Category 3 comments (17 responses) conveyed the general impression that, in the engineering profession, quality was a more important consideration than quantity and, therefore, productivity measurement of professionals should not be attempted. Category 3 and category 5 comments tended to reaffirm the generally negative responses of a group of respondents to the attitudinal questions (questions 10-12). It was the belief of this group that productivity measurement in the design section was infeasible and would be counterproductive even if the program were kept at the base level.

Category 4 comments (14 responses) indicated that managers of the design section were concerned about the fact that less than 40 percent of their section's time was spent on design which they perceived as their primary function. They felt that the productivity of other duties of design section personnel (i.e., training sessions, briefings, staff meetings, consultant services) needed to be measured.

Category 6 comments (3 responses) indicated that if productivity measurement was attempted it should be kept simple, utilizing only one good measure. It was the belief of the researchers that the diversity of section objectives rendered this approach infeasible; however, we agreed that the measures should be simple and easy to track, thereby minimizing costs to administer the program.

Category 7 (3 responses) and category 8 comments (2 responses) indicated the disparity involved with using labor cost as an input measure. Some respondents felt that labor cost was a good input measure since it discriminated between the productivity of a higher paid employee and that of a lower paid employee. However, based on the results of the analysis of the attitudinal questions, the general opinion of respondents was that manhours were a better input measure than labor cost since labor cost is an uncontrollable variable. It is the opinion of the researchers that both input measures provide useful information when used in productivity measurement.

Chapter 5

CONCLUSIONS AND RECOMMENDATIONS

This chapter is organized into two sections, conclusions and recommendations. The first section addresses the research questions set forth in Chapter 2 and general conclusions are drawn from the overall research. The second section presents several general recommendations derived from this research effort and recommendations for further research.

CONCLUSIONS

Research Questions Answered

1. What output measures are appropriate to measure progress towards operational objectives of the design section of a base level Air Force Civil Engineering organization?

After identifying the objectives of the BCE design section, 26 output measures were identified as possible indicators of performance. These output measures were derived from information currently compiled or recorded in Air Force Civil Engineering (AFCE) organizations (see Appendix B). Through an iterative and discriminating process, a final list of 19 output measures was selected for incorporation into the research questionnaire. The analysis of the data collected from the questionnaires identified four output measures which managers in the field considered useful to measure progress toward operational objectives of the design section. The output measures identified were:

1. Total estimated dollar amount of contract projects and in-house work orders designed.

2. Total number of projects designed (complete and ready for acquisition action).

3. Total number of facility inspections and utility systems surveys completed.

4. Total estimated dollar amount of architect-engineer (A-E) design acquisition packages prepared.

In addition, the most experienced base level AFCE managers (over 10 years experience in a BCE organization) identified 2 other output measures which may be considered useful. These are:

1. Total contract funds obligated (i.e., Military Construction Program and Operations and Maintenance).

2. Number of work orders reviewed and/or evaluated.

2. *What productivity measures can be developed from these output measures using currently documented inputs?*

The only quantifiable inputs currently documented for the design section were direct labor cost and labor man-hours. Thus, the productivity measures developed could deal only with labor inputs. More comprehensive productivity measures could be developed using other measurable inputs which are currently not documented. Other measurable inputs include equipment, facilities, and materials used. For this research, we assumed that the differences in equipment and facilities available to the various design sections were not significant. Similarly, we assumed that the amount of materials used did not significantly affect the labor productivity. Thus, labor cost and manhours were the only input measures included in formulating the productivity measures.

The final list of 19 output measures were used as numerators and the 2 input measures as denominators in formulating 38 productivity measures which were incorporated into the research questionnaire (see Appendix C, Part I).

3. Are the selected productivity measures considered valid by those who will use them?

The answer to this research question is based on the analysis of the responses to a survey of base level AFCE managers who would monitor and/or control the productivity of the design section (i.e., the Base Civil Engineer, the Industrial Engineer, and the Chief of Design). The validity of the productivity measures was determined by asking those surveyed if the measures would be useful to them as managers of the design section. The analysis of the data provided by 129 respondents indicated that six (6) productivity measures were considered to be useful and appropriate to the objectives of the design section. These measures were:

1. Total estimated dollar amount of contract projects and in-house work orders designed divided by total design manhours.

2. Total number of projects designed (complete and ready for acquisition action) divided by total design manhours.

3. Total number of facility inspections and utility systems surveys completed divided by total manhours to complete surveys and inspections.

4. Total estimated dollar amount of architect-engineer (A-E) design acquisition packages prepared divided by total manhours to prepare.

5. Total estimated dollar amount of contract projects and in-house work orders designed divided by total design labor cost.

6. Total number of projects designed (complete and ready for acquisition action) divided by total design labor cost.

Two additional measures were identified by two prominent partial samples: the Base Civil Engineers and the most experienced managers (over 10 years in a BCE organization). These measures are listed below and may be considered useful to the managers of the design section:

1. Total contract funds obligated (i.e., Military Construction Program and Operations and Maintenance) divided by total design manhours associated with the contract funds obligated.

2. Number of work orders reviewed and/or evaluated divided by total manhours required for review and/or evaluation.

General Conclusions

Questions 10, 12, and 13 of the questionnaire provided useful information from which to draw some general conclusions concerning productivity measurement in the design section. The analysis of question 10 indicated that nearly 75 percent of the respondents agreed in some degree that measures were needed to detect productivity trends in the design section. However, as the analysis of question 12 indicated, the respondents had a less enthusiastic opinion for a formal productivity program with only 51.2 percent of the respondents agreeing in some degree. These two facts plus the comments provided in the open-ended portion (question 13), led the researchers to the following general conclusions.

1. There is a general opinion among base level AFCE managers that productivity measures are needed for the design section, but these managers are apprehensive about developing and using these measures. This apprehension

results from the possibility of additional work requirements (in the form of collecting, analyzing, and reporting on the productivity measures) which may arise from the formalization of the productivity program. Most design section managers would prefer to tailor productivity measurement on their own and keep the information on a local level rather than having to work another controlled report.

2. Each base design section operates in an environment (both internal and external) which is different from other design sections. For this reason, not all measures would be applicable to all design sections. Also, comparing several design sections based on the productivity measures developed would not be advisable. This fact gives further credence to the belief that productivity measurement should be kept at the base level and not formalized into a MAJCOM/ USAF controlled program.

3. If productivity measures are used, they must be a means to improve management rather than ends in themselves. The quality of the output which leads to the accomplishment of base missions must always be as important, if not more important, than achieving a quantitative standard. Quality must be maintained while attempting to improve productivity because an ineffective organization is not a productive organization.

RECOMMENDATIONS

Based on our analysis and subsequent conclusions, general recommendations and recommendations for further research are in order.

General Recommendations

1. We recommend that the six (6) productivity measures identified by this research as being useful to managers of the base level Air Force Civil Engineering (AFCE) organization design section be used as a starting basis to detect productivity trends and set section objectives once standards have been established. One of the problems with current design section objectives is that they are too vague and progress towards their accomplishment cannot be measured. After productivity measures have been used for a period of time (say, one year), standards for performance can be established by design section managers and future productivity measures can be compared to past standards to detect changes in productivity. This will help managers to objectively identify efficient operations, to identify and take effective, timely remedial action in potential trouble areas, and to improve productivity by revising methods and standards of operation.

2. We recommend that the Base Engineer Automated Management System (BEAMS) be used to track output and input measures and to monitor the productivity of the design

section rather than manual tabulation. This will help ease the administrative time necessary to control and monitor the performance of this section.

3. At the outset, these productivity measures should not be used in conjunction with a formal program, nor should their use be controlled by a higher level of command than the base. Base managers should use these measures as a starting point in developing a productivity program and should tailor the program to meet the specific needs of their section. Once the program has been established, measures which are generic to all design sections can be identified to be used as a means of comparing various design sections. An attempt at formalizing (reporting to higher levels of command) the productivity program should only be made after the various base programs have been well established and standards developed. However, comparing the design sections of different bases is only feasible if they function within similar environments (i.e., engineers with similar experience, funding of similar projects, minimal interference by "command interest" projects, etc.).

4. These productivity measure should not be used to evaluate the performance of individual engineers since this was not the intent in their development.

5. Productivity measurement should be kept simple utilizing several useful measures which reflect the objectives of the individual design section. These measures

should be easy to control and monitor using existing management information systems with slight modifications when required.

Recommendations for Further Research

1. Data should be gathered to analyze the six productivity measures identified in this research to determine if there is a correlation between the output and input measures for each productivity measure. If a correlation can be established, then the productivity measures can be used as an aid in future planning by improving the planned allocation of resources; by improving the evaluation of effects of policy constraints and other externally imposed constraints; and, by improving the integration of present policies with contingency requirements. In short, if a correlation between output and input can be shown, one can be used to predict the other. For example, managers could determine the potential effect of current manpower policies on the ability of the design section to meet its objectives.

2. Research should be done to improve the methods of estimating the manhours required for accomplishing given outputs so that the alternate method of productivity measurement (actual manhours/estimated manhours) can be used. This method of productivity measurement is most feasible for the qualitative (or hard to quantify) functions of design section personnel.

3. Productivity measures should be developed for the other branches and sections of the base civil engineering organization.

4. Output measures and productivity measures need to be developed to evaluate the performance of individual engineers.

5. Current Air Force interest and much of this research have focused on the productivity of design activities which may require approximately 40 percent of the engineer's time (25:69). Further research needs to be conducted to identify those activities which comprise the other 60 percent of the engineer's time and to develop productivity measures to evaluate those activities. At least, the study should identify the activities to allow for more efficient management of his time.

APPENDIX A

PANELS OF EXPERTS FQR QUESTIONNAIRE
DEVELOPMENT

PART I

PANEL OF AFIT SCHOOL OF SYSTEMS AND LOGISTICS FACILITIES MANAGEMENT STUDENTS

NAME/RANK	CUMULATIVE TIME IN BCE
Grantland W. Johns, Major	12
Richard L. Williams, Captain	10
Thomas H. Gross, Captain	8
Calder D. Kohlhaas, Captain	5
Charles R. Hatch, GS-12	10

The draft of the productivity measurement questionnaire was provided to a panel of Air Force Civil Engineering (AFCE) managers enrolled in a graduate degree program (Facilities Management) at the Air Force Institute of Technology (AFIT) School of Systems and Logistics. Each individual was selected based on the fact that each had come to AFIT from a base or MAJCOM civil engineering organization and had been officially recognized for outstanding performance in that unit; each had been associated with or managed a base level AFCE design section; and, each had been in the AFCE career field for a substantial time (ranging from 5 to 12 years).

PART II

PANEL OF SELECTED AFIT SCHOOL OF CIVIL ENGINEERING FACULTY

NAME/RANK	POSITION
Peter Walsh, Major, USAF	Course Director, Department of Management Applications
Jack Baker, Captain, USAF	Instructor, Financial Management Course, Department of Management Applications

Following the consolidation of review comments from the panel of AFIT School of Logistics Facilities Management graduate students (Appendix A, Part I), a revised copy of the questionnaire used in this study was presented to selected members of the AFIT School of Civil Engineering faculty for additional criticism and recommendations for improvement. This review by the "experts" in the AFCE career field was the culmination of an iterative process to identify reasonable productivity measures for a base level civil engineering design section.

APPENDIX B

LIST OF OUTPUT MEASURES

	OUTPUT MEASURE	SOURCE (Suggested by/Required by/ Collected in)
1.	Total estimated dollar amount of contract projects and in-house work orders designed.	BEAMS, AFR 86-1, AFR 89-1
2.	Total contract funds obligated (i.e., Military Construction Program, Military Family Housing, Operations & Maintenance, etc.).	BEAMS, Commander's Update, AFR 86-1, AFR 89-1, USAF MCP Guidance
3.	Total O&M contract funds obligated (EEIC 52X).	BEAMS, AFR 86-1, AFR 89-1, Commander's Update
4.	Total O&M maintenance and repair funds obligated (EEIC 521 and 522).	BEAMS, AFR 86-1, AFR 89-1, Commander's Update
5.	Total O&M minor construction funds obligated (EEIC 529).	BEAMS, AFR 86-1, AFR 89-1, Commander's Update
6.	Total estimated dollar amount of project documents (DD 1391/ 1391c) completed.	BEAMS, AFR 86-1, AFR 89-1
7.	Total number of projects designed (complete and ready for acquisition action).	BEAMS, AFR 86-1, AFR 89-1, Commander's Update
8.	Total number of facility inspections and utility systems surveys completed.	AFIT panel of grad students
9.	Total number of special technical studies and reports completed.	Master's thesis (25)
10.	Total funds expensed on contract change orders.	AFIT faculty

	OUTPUT MEASURE	SOURCE (Suggested by/Required by/ Collected in)
11.	Number of contract change orders.	AFIT faculty
12.	Total estimated dollar amount of in-house work orders designed.	Researchers
13.	Total service contract funds obligated.	BEAMS
14.	Number of environmental assessments (EAs) and environmental impact statements (EISs) completed.	AFIT faculty
15.	Total estimated dollar amount of architect-engineer (A-E) design acquisition packages prepared.	BEAMS
16.	Total A-E design funds obligated.	AFR 86-1
17.	Number of work orders reviewed and/or evaluated.	AFIT panel of grad students
18.	Number of technical reviews accomplished on designed projects.	Researchers
19.	Number of military family housing (MFH) inspections completed.	Researchers
20.	Pages of project specifications.	AFIT faculty
21.	Total hours of supplemental training completed.	DOD Instructions (43)
22.	Number of professional educational courses completed.	Researchers

OUTPUT MEASURE	SOURCE (Suggested by, Required by, Collected in)
23. Total hours construction inspections completed.	Researchers
24. Total number of oral presentations made.	Researchers
25. Total number of journal articles written.	Researchers
26. Hours of training sessions taught/conducted.	Researchers

APPENDIX C

PRODUCTIVITY MEASURE QUESTIONNAIRE

PART I

SURVEY COVER LETTER AND QUESTIONNAIRE

DEPARTMENT OF THE AIR FORCE
AIR FORCE INSTITUTE OF TECHNOLOGY (ATC)
WRIGHT-PATTERSON AIR FORCE BASE, OHIO 45433

REPLY TO ATTN OF: LSGR (LSSR 16-80)/Capt K. Kaneda/1st Lt R. Wallett/ AUTOVON 78-54698

SUBJECT: Base Level Civil Engineering Design Section Productivity Measure Questionnaire

TO:

1. The attached questionnaire was prepared by a research team at the Air Force Institute of Technology, Wright-Patterson AFB, Ohio. The purpose of this questionnaire is to acquire data concerning the perceptions of various base civil engineering (BCE) managers as to what productivity measures are appropriate for the BCE design section.

2. You are requested to provide an answer or comment for each question. Headquarters USAF Survey Control Number 80-53 has been assigned to this questionnaire. Your participation in this research is voluntary.

3. Your responses to the questions will be held confidential. Please remove this cover sheet before returning the completed questionnaire. Your cooperation in providing this data will be appreciated and will be very beneficial in measuring the progress of the design section towards the operation objectives of a base level Air Force Civil Engineering organization. Please return the completed questionnaire in the attached envelope within one week after receipt.

LEWIS M. ISRAELITT, Colonel, USAF
Dean
School of Systems and Logistics

2 Atch
1. Questionnaire
2. Return Envelope

PRODUCTIVITY MEASUREMENT

Part I: Individual Information

1. Current Grade/Rank: ______________________________

2. Current position: (circle answer)

   a. Base Civil Engineer
   b. Chief, Design section
   c. Chief, Industrial Engineering branch
   d. Other (please specify)

3. Length of time in current position: ____Yrs.____Mos.

4. Cumulative length of time (not necessarily consecutive in any USAF Civil Engineering organization:

   ____Yrs.____Mos.

5. Highest level of education attained: (circle answer)

   a. Completed high school
   b. 1-4 years college, no degree
   c. Associate's degree
   d. Bachelor's degree
   e. Graduate School, no degree
   f. Master's degree
   g. Doctorate's degree
   h. Other (please specify) ________________________

Part II: General Organization Information

6. Major Command: ________________________________

7. Geographical location of your base: (circle answer)

   a. Northeast
   b. North Central
   c. Southeast
   d. Northwest
   e. South Central
   f. Southwest

Part II: General Organization Information (cont.)

8. Number of personnel assigned to the design section:
   a. Engineers ______
   b. Engineering Technicians ______
   c. Administrative ______
   d. Other ______

9. Is the Base Engineer Automated Management System (BEAMS) currently being used at your base? (Yes or No) ______

NOTE: The various output and input measures used in Part III of this questionnaire is based on the assumption that the data is either available in BEAMS or collected as part of other BCE management information systems.

(PLEASE PROCEED TO THE NEXT PAGE)

Part III: Productivity

The following definitions apply for concepts and terms used in the remaining portion of this questionnaire:

Output - the quantity of goods, products, and services produced or provided during a specified period of time.

Input - the quantity of resources used by the organization during a specified period of time; only manhours and labor cost will be used in this questionnaire.

Productivity - a ratio of output to input.

Design - includes review of (1) programming and planning documents, (2) review of record drawings, (3) necessary site visits to verify actual conditions, (4) meetings with using agencies to insure that their functional requirements are met, (5) necessary research to insure compliance with USAF regulations, (6) development of drawings and specifications, (7) required final coordination and approval procedures, and (8) compliance with appropriate project review comments.

Questions 10-12: Please answer by placing an "X" above what you feel is the appropriate category (scale shown below) in terms of usefulness to the base civil engineering organization.

[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
1	2	3	4	5	6	7
Strongly Agree			Undecided			Strongly Disagree

10. Productivity is the ratio of goods and/or services produced to the resources used (output ÷ input). Measures are needed in the base level civil engineering organization to detect productivity trends.

[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
1	2	3	4	5	6	7

11. If productivity measures were required to be formulated and utilized by management, the following would be most appropriate for the BCE <u>design</u> section:

a. Total estimated dollar amount of contract projects and in-house work orders designed ÷ total design manhours for projects and work orders designed.

[ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5 [ ] 6 [ ] 7

b. Total contract funds obligated (i.e., Military Construction and Operations and Maintenance) ÷ total design manhours associated with contract gunds obligated.

[ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5 [ ] 6 [ ] 7

c. Total Operations and Maintenance (O&M) contract funds obligated (EEIC 52X) ÷ total O&M design manhours.

[ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5 [ ] 6 [ ] 7

d. Total O&M maintenance and repair (M&R) contract funds obligated (EEICs 521 and 522) ÷ total M&R design manhours.

[ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5 [ ] 6 [ ] 7

e. Total O&M minor construction (MC) contract funds (EEIC 529) obligated ÷ total MC design manhours.

[ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5 [ ] 6 [ ] 7

f. Total estimated dollar amount of project documents (DD 1391/1391c) completed ÷ total manhours spent preparing the project documents.

[ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5 [ ] 6 [ ] 7

g. Total number of projects designed (complete and ready for acquisition action) ÷ total design manhours.

[ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5 [ ] 6 [ ] 7

h. Total number of facility inspections and utility systems surveys completed ÷ total manhours to complete surveys and inspections.

[ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5 [ ] 6 [ ] 7

i. Total number of special technical studies ÷ total manhours to accomplish studies.

[ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5 [ ] 6 [ ] 7

j. Total funds expensed on contract change orders ÷ total design manhours for change orders.

[ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5 [ ] 6 [ ] 7

k. Number of contract change orders ÷ total design manhours for change orders.

[ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5 [ ] 6 [ ] 7

l. Total estimated dollar amount of in-house work orders designed ÷ total design manhours to design work orders.

[ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5 [ ] 6 [ ] 7

m. Total service contract funds obligated ÷ total manhours to prepare the service contracts.

[ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5 [ ] 6 [ ] 7

n. Number of environmental assessments (EAs) and environmental impact statements (EISs) completed ÷ total manhours required to prepare EAs and EISs.

[ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5 [ ] 6 [ ] 7

o. Total estimated dollar amount of architect-engineer (A-E) design acquisition packages prepared ÷ total manhours to prepare.

[ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5 [ ] 6 [ ] 7

p. Total A-E design funds obligated ÷ total manhours to prepare obligated A-E design packages.

[ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5 [ ] 6 [ ] 7

q. Number of work orders reviewed and/or evaluated ÷ total manhours required for review and evaluation.

[ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5 [ ] 6 [ ] 7

r. Number of technical reviews accomplished on designed projects ÷ total manhours required for review.

[ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5 [ ] 6 [ ] 7

s. Number of military family housing (MFH) inspections completed ÷ total manhours to complete inspections.

[ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5 [ ] 6 [ ] 7

NOTE: The remaining productivity measures will utilize the same output measures above (items 11a through 11s) but with a different input measure (labor cost) in the denominator.

t. Total estimated dollar amount of contract projects and in-house work orders designed ÷ total design labor cost.

[ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5 [ ] 6 [ ] 7

u. Total contract funds obligated (i.e., Military Construction Program and Operations and Maintenance) ÷ total design labor cost for contract funds.

[ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5 [ ] 6 [ ] 7

v. Total O&M contract funds obligated (EEIC 52X) ÷ total labor cost to design obligated O&M projects.

[ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5 [ ] 6 [ ] 7

w. Total O&M maintenance and repair (M&R) contract funds obligated (EEICs 521 and 522) ÷ total M&R design labor cost.

[ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5 [ ] 6 [ ] 7

x. Total O&M minor construction (MC) contract funds (EEIC 529) obligated ÷ total MC design labor cost.

[ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5 [ ] 6 [ ] 7

y. Total estimated dollar amount of project documents (DD 1391/1391c) completed ÷ total labor cost to complete project documents.

[ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5 [ ] 6 [ ] 7

z. Total number of projects designed (complete and ready for acquisition action) ÷ total design labor cost.

[ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5 [ ] 6 [ ] 7

aa. Total number of facility inspections and utility system surveys completed ÷ total labor cost to complete surveys and inspections.

[ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5 [ ] 6 [ ] 7

bb. Total number of special technical studies $\div$ total labor cost to accomplish studies.

[ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5 [ ] 6 [ ] 7

cc. Total funds expensed on contract change orders $\div$ total design labor cost for change orders.

[ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5 [ ] 6 [ ] 7

dd. Number of contract change orders $\div$ total labor cost for change orders.

[ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5 [ ] 6 [ ] 7

ee. Total estimated dollar amount of in-house work orders designed $\div$ total design labor cost to design work orders.

[ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5 [ ] 6 [ ] 7

ff. Total service contract funds obligated $\div$ total labor cost to prepare the service contracts.

[ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5 [ ] 6 [ ] 7

gg. Number of environmental assessments (EAs) and environmental impact statements (EISs) completed $\div$ total labor cost required to prepare EAs and EISs.

[ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5 [ ] 6 [ ] 7

hh. Total estimated dollar amount of A-E design acquisition packages prepared $\div$ total labor cost to prepare.

[ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5 [ ] 6 [ ] 7

ii. Total A-E design funds obligated ÷ total labor cost to prepare obligated A-E design packages.

[ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5 [ ] 6 [ ] 7

jj. Number of work orders reviewed and/or evaluated ÷ total labor cost required for review and/or evaluation.

[ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5 [ ] 6 [ ] 7

kk. Number of technical reviews accomplished on designed projects ÷ total labor cost required for review.

[ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5 [ ] 6 [ ] 7

ll. Number of military family housing (MFH) inspections completed ÷ total labor cost to complete inspections.

[ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5 [ ] 6 [ ] 7

12. A formal productivity program is needed by management in the base level civil engineering organization.

[ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5 [ ] 6 [ ] 7

(PLEASE PROCEED TO THE NEXT PAGE)

13. List any additional productivity measures that you have used or feel could be used to assist management and which relates to the BCE design section.

<u>COMMENTS</u>:

THANK YOU FOR YOUR COOPERATION

Please return completed questionnaire in the enclosed envelope. Use official mail as appropriate.

PART 2

LIST OF ADDRESSEES

		Designated CES Organization Number
1.	**Air Defense Command (ADC)**	
	Duluth International Airport MN 55814	4787
	Hancock Field NY 13225	4789
	Kingsley Field OR 97601	827
2.	**Air Force Logistics Command (AFLC)**	
	Hill AFB UT 84056	2849
	McClellan AFB CA 95652	2852
	Robbins AFB GA 31098	2853
	Tinker AFB OK 73145	2854
	Wright-Patterson AFB OH 45433	2750
3.	**Air Force Systems Command (AFSC)**	
	Edwards AFB CA 93523	6510
	Eglin AFB FL 32542	3202
	Hanscom AFB MA 01731	3245
	Patrick AFB FL 32925	6550
4.	**Air Training Command (ATC)**	
	Chanute AFB IL 61868	3345
	Columbus AFB MS 39701	14
	Goodfellow AFB TX 76903	3480
	Keesler AFB MS 39534	3380
	Laughlin AFB TX 78840	47
	Lowry AFB CO 80230	3415
	Mather AFB CA 95655	323
	Maxwell AFB AL 36112	3800
	Reese AFB TX 79489	64
	Sheppard AFB TX 73611	3750
	Williams AFB AZ 85224	80

	Designated CES Organization Number
5. Military Airlift Command (MAC)	
Altus AFB OK 73521	443
Andrews AFB MD 20331	76
Bolling AFB DC 20332	1100
Charleston AFB SC 29404	437
Dover AFB DE 19901	436
Kirtland AFB NM 87117	1606
Little Rock AFB AR 72076	314
McChord AFB WA 98438	62
McGuire AFB NJ 08641	438
Norton AFB CA 92409	63
Pope AFB NC 28308	317
Scott AFB IL 62225	375
Travis AFB CA 94535	60
6. Separate Operating Agency	
U.S. Air Force Academy CO 80840	7625
7. Strategic Air Command (SAC)	
Barksdale AFB LA 71110	2
Beale AFB CA 95903	100
Blytheville AFB AR 72315	97
Carswell AFB TX 76127	7
Castle AFB CA 95342	93
Dyess AFB TX 79607	96
Ellsworth AFB SD 57706	44
Fairchild AFB WA 99011	92
F.E. Warren AFB WY 82001	90
Grand Forks AFB ND 58205	321
Griffiss AFB NY 13441	416
Grissom AFB IN 46971	305
K.I. Sawyer AFB MI 49843	410
Loring AFB ME 04751	42
Malmstrom AFB MT 59402	341
March AFB CA 92518	22
McConnell AFB KS 67221	381
Minot AFB ND 58701	91
Offutt AFB NE 68113	3902
Pease AFB NH 03801	509
Peterson AFB CO 80914	46
Plattsburg AFB NY 12903	380
Vandenberg AFB CA 93437	4392
Whiteman AFB MO 65301	351
Wurtsmith AFB MI 48753	379

	Designated CES Organization Number
8. Tactical Air Command (TAC)	
Bergstrom AFB TX 78743	67
Cannon AFB NM 88101	27
Davis Monthan AFB AZ 85707	355
England AFB LA 71301	23
George AFB CA 92392	35
Gila Bend AFS AZ	58
Holloman AFB NM 88330	49
Homestead AFB FL 33039	31
Hurlburt Field FL 32544	834
Indian Springs AF AUX FLD NV 89018	57
Langley AFB VA 23665	1
Luke AFB AZ 85309	58
MacDill AFB FL 33608	56
Moody AFB GA 31601	347
Mountain-Home AFB ID 83648	366
Myrtle Beach AFB SC 29577	354
Nellis AFB NV 89191	57
Seymour Johnson AFB NC 27531	4
Shaw AFB SC 29152	363
Tyndall AFB FL 32401	4756

APPENDIX D

SAMPLE SPSS SUBPROGRAMS AND PROJECT DATA MASTER FILE

PART I

SAMPLE SPSS SUBPROGRAM CONDESCRIPTIVE

```
$       LIMITS   ,,,15K
$       SELECT   SPSS/SPSS
RUN NAME         QUEST1
VARIABLE LIST    N1 TO N48
INPUT FORMAT     FIXED (2(1X,A1),2(F6.2),2(1X,A1),F3.0,1X,A1,16(F2.0)/24(F2.0))
N OF CASES       129
INPUT MEDIUM     CARD
VAR LABELS       N1, GRADE/
                 N2, POSITION/
                 N3, TIME IN CURRENT POSITION/
                 N4, CUM TIME IN BCE/
                 N5, EDUCATION LEVEL/
                 N6, MAJCOM/
                 N7, TOTAL NBR IN DSGN SECTION/
                 N8, BEAMS/
                 N9, PROD MEASURES NEEDED IN BCE/
                 N10,CWE PROJS & WORK ORDERS DSGND BY DSGN MHRS/
                 N11,TOTAL CONTR FUNDS OBLIGATED BY DSGN MHRS/
                 N12,EEIC 52X FUNDS OBLIGATED BY DSGN MHRS/
                 N13,M&R CONTR FUNDS OBLIGATED BY DSGN MHRS/
                 N14,MC CONTR FUNDS OBLIGATED BY DSGN MHRS/
                 N15,CWE PROJS DOCS COMPLETED BY PREP MHRS/
                 N16,NBR PROJS DSGND BY DSGN MHRS/
                 N17,NBR FAC SURVEYS COMPLETED BY SURVEY MHRS/
                 N18,TOTAL NBR SPEC STUDIES BY MHRS/
                 N19,TOTAL UA CONTR CHANGE ORDERS BY DSGN MHRS/
                 N20,NBR CONTR CHANGE ORDERS BY DSGN MHRS/
                 N21,CWE IH WORK ORDERS DSGND BY DSGN MHRS/
                 N22,SVC CONTR FUNDS OBLIGATED BY PREP MHRS/
                 N23,NBR EA & EIS COMPLETED BY PREP MHRS/
                 N24,CWE A-E DSGN PKGS COMPLETED BY PREP MHRS/
                 N25,A-E DSGN FUNDS OBLIGATED BY PREP MHRS/
                 N26,NBR WORK ORDERS EVALUATED BY REVIEW MHRS/
                 N27,NBR TECH REVIEWS COMPLETED BY REVIEW MHRS/
                 N28,NBR MFH INSPECT COMPLETED BY INSPECT MHRS/
                 N29,CWE PROJS & WORK ORDERS DSGND BY DSGN LBR COST/
                 N30,TOTAL CONTR FUNDS OBLIGATED BY DSGN LBR COST/
                 N31,EEIC 52X FUNDS OBLIGATED BY DSGN LBR COST/
                 N32,M&R CONTR FUNDS OBLIGATED BY DSGN LBR COST/
                 N33,MC CONTR FUNDS OBLIGATED BY DSGN LBR COST/
                 N34,CWE PROJ DOCS COMPLETED BY PREP LBR COST/
                 N35,NBR PROJS DSGND BY DSGN LBR COST/
                 N36,NBR FAC SURVEYS COMPLETED BY SURVEY LBR COST/
                 N37,TOTAL NBR SPEC STUDIES BY LBR COST/
```

```
                  N38,TOTAL OA CONTR CHANGE ORDERS BY DSGN LBR COST/
                  N39,NBR CONTR CHANGE ORDERS BY DSGN LBR COST/
                  N40,CWE IH WORK ORDERS DSGND BY PREP LBR COST/
                  N41,SVC CONTR FUNDS OBLIGATED BY PREP LBR COST/
                  N42,NBR EA & EIS COMPLETED BY PREP LBR COST/
                  N43,CWE A-E DSGN PKGS COMPLETED BY PREP LBR COST/
                  N44,A-E DSGN FUNDS OBLIGATED BY PREP LBR COST/
                  N45,NBR WORK ORDERS EVALUATED BY REVIEW LBR COST/
                  N46,NBR TECH REVIEWS COMPLETED BY REVIEW LBR COST/
                  N47,NBR MFH INSPECT COMPLETED BY INSPECT LBR COST/
                  N48,FORMAL BCE PRODUCTIVITY PROGRAM NEEDED?
VALUE LABELS      N1 (1) MILITARY (2) CIVILIANS/
                  N2 (1) BASE CIVIL ENGINEER (2) CHIEF OF DESIGN
                  (3) CHIEF OF IE (4) OTHER/
                  N5 (1) HIGH SCHOOL (2) COLLEGE, NO DEGREE (3) ASSOCIATE'S DEGREE
                  (4) BACHELOR'S DEGREE (5) GRAD SCH, NO DEGREE
                  (6) MASTER'S DEGREE (7) DOCTORATE'S DEGREE (8) OTHER/
                  N6 (1) ADC (2) AFLC (3) AFSC (4) ATC (5) MAC
                  (6) SAC (7) TAC (8) SOA/
                  N8 (1) YES (2) NO/
                  N9 TO N48
                  (1) STRONGLY AGREE
                  (2) AGREE
                  (3) SLIGHTLY AGREE
                  (4) UNDECIDED
                  (5) SLIGHTLY DISAGREE
                  (6) DISAGREE
                  (7) STRONGLY DISAGREE
SAMPLE            0.50
CONDESCRIPTIVE    N9 TO N48
STATISTICS        ALL
READ INPUT DATA
$       SELECTA   80A050/QUEST6,R
*RECODE           N1
                  ('A','B','C','D','E','F','G','H','I','J','K'=1)/
                  N2,N5,N6,N8('A'=1)('B'=2)('C'=3)('D'=4)('E'=5)
                  ('F'=6)('G'=7)('H'=8)
FREQUENCIES       GENERAL=ALL
OPTIONS           3,8,9
CROSSTABS         TABLES=N9 TO N48 BY N1
FINISH
$       ENDJOB
```

PART II

SAMPLE SPSS SUBPROGRAM FREQUENCIES

```
$       SELECT   SPSS/SPSS
$       LIMITS   ,,,15K
RUN NAME         QUEST1
VARIABLE LIST    N1 TO N48
INPUT FORMAT     FIXED (2(1X,A1),2(F6.2),2(1X,A1),F3.0,1X,A1,16(F2.0)/24(F2.0))
N OF CASES       129
INPUT MEDIUM     CARD
VAR LABELS       N1, GRADE/
                 N2, POSITION/
                 N3, TIME IN CURRENT POSITION/
                 N4, CUM TIME IN BCE/
                 N5, EDUCATION LEVEL/
                 N6, MAJCOM/
                 N7, TOTAL NBR IN DSGN SECTION/
                 N8, BEAMS/
                 N9, PROD MEASURES NEEDED IN BCE/
                 N10,CWE PROJS & WORK ORDERS DSGND BY DSGN MHRS/
                 N11,TOTAL CONTR FUNDS OBLIGATED BY DSGN MHRS/
                 N12,EEIC 52X FUNDS OBLIGATED BY DSGN MHRS/
                 N13,M&R CONTR FUNDS OBLIGATED BY DSGN MHRS/
                 N14,MC CONTR FUNDS OBLIGATED BY DSGN MHRS/
                 N15,CWE PROJS DOCS COMPLETED BY PREP MHRS/
                 N16,NBR PROJS DSGND BY DSGN MHRS/
                 N17,NBR FAC SURVEYS COMPLETED BY SURVEY MHRS/
                 N18,TOTAL NBR SPEC STUDIES BY MHRS/
                 N19,TOTAL OA CONTR CHANGE ORDERS BY DSGN MHRS/
                 N20,NBR CONTR CHANGE ORDERS BY DSGN MHRS/
                 N21,CWE IH WORK ORDERS DSGND BY DSGN MHRS/
                 N22,SVC CONTR FUNDS OBLIGATED BY PREP MHRS/
                 N23,NBR EA & EIS COMPLETED BY PREP MHRS/
                 N24,CWE A-E DSGN PKGS COMPLETED BY PREP MHRS/
                 N25,A-E DSGN FUNDS OBLIGATED BY PREP MHRS/
                 N26,NBR WORK ORDERS EVALUATED BY REVIEW MHRS/
                 N27,NBR TECH REVIEWS COMPLETED BY REVIEW MHRS/
                 N28,NBR MFH INSPECT COMPLETED BY INSPECT MHRS/
                 N29,CWE PROJS & WORK ORDERS DSGND BY DSGN LBR COST/
                 N30,TOTAL CONTR FUNDS OBLIGATED BY DSGN LBR COST/
                 N31,EEIC 52X FUNDS OBLIGATED BY DSGN LBR COST/
                 N32,M&R CONTR FUNDS OBLIGATED BY DSGN LBR COST/
                 N33,MC CONTR FUNDS OBLIGATED BY DSGN LBR COST/
                 N34,CWE PROJ DOCS COMPLETED BY PREP LBR COST/
                 N35,NBR PROJS DSGND BY DSGN LBR COST/
                 N36,NBR FAC SURVEYS COMPLETED BY SURVEY LBR COST/
                 N37,TOTAL NBR SPEC STUDIES BY LBR COST/
                 N38,TOTAL OA CONTR CHANGE ORDERS BY DSGN LBR COST/
```

```
                 N39,NBR CONTR CHANGE ORDERS BY DSGN LBR COST/
                 N40,CWE IH WORK ORDERS DSGND BY PREP LBR COST/
                 N41,SVC CONTR FUNDS OBLIGATED BY PREP LBR COST/
                 N42,NBR EA & EIS COMPLETED BY PREP LBR COST/
                 N43,CWE A-E DSGN PKGS COMPLETED BY PREP LBR COST/
                 N44,A-E DSGN FUNDS OBLIGATED BY PREP LBR COST/
                 N45,NBR WORK ORDERS EVALUATED BY REVIEW LBR COST/
                 N46,NBR TECH REVIEWS COMPLETED BY REVIEW LBR COST/
                 N47,NBR MFH INSPECT COMPLETED BY INSPECT LBR COST/
                 N48,FORMAL BCE PRODUCTIVITY PROGRAM NEEDED?
VALUE LABELS     N1 (1) MILITARY (2) CIVILIANS/
                 N2 (1) BASE CIVIL ENGINEER (2) CHIEF OF DESIGN
                 (3) CHIEF OF IE (4) OTHER/
                 N5 (1) HIGH SCHOOL (2) COLLEGE, NO DEGREE (3) ASSOCIATE'S DEG
                 (4) BACHELOR'S DEGREE (5) GRAD SCH, NO DEGREE
                 (6) MASTER'S DEGREE (7) DOCTORATE'S DEGREE (8) OTHER/
                 N6 (1)ADC (2) AFLC (3) AFSC (4) ATC (5) MAC
                 (6) SAC (7) TAC (8) SOA/
                 N8 (1) YES (2) NO/
                 N9 TO N48  (1) STRONGLY AGREE (2) AGREE (3) SLIGHTLY AGREE
                 (4) UNDECIDED (5) SLIGHTLY DISAGREE (6) DISAGREE
                 (7) STRONGLY DISAGREE
RECODE           N2('A','B','C','D'=1)
*SELECT IF       (N2 EQ 1)
FREQUENCIES      GENERAL=N9 TO N48
OPTIONS          3,8,9
STATISTICS       ALL
READ INPUT DATA
$       SELECTA 80A050/QUEST6,R
CROSSTABS        TABLES=N9 TO N48 BY N2
FINISH
$       ENDJOB
```

PART III

SAMPLE SPSS SUBPROGRAM CROSSTABS

```
$       SELECT  SPSS/SPSS
$       LIMITS  ,,,15K
RUN NAME        QUEST1
VARIABLE LIST   N1 TO N48
INPUT FORMAT    FIXED (2(1X,A1),2(F6.2),2(1X,A1),F3.0,1X,A1,16(F2.0)/24(F2.0))
N OF CASES      129
INPUT MEDIUM    CARD
VAR LABELS      N1, GRADE/
                N2, POSITION/
                N3, TIME IN CURRENT POSITION/
                N4, CUM TIME IN BCE/
                N5, EDUCATION LEVEL/
                N6, MAJCOM/
                N7, TOTAL NBR IN DSGN SECTION/
                N8, BEAMS/
                N9, PROD MEASURES NEEDED IN BCE/
                N10,CWE PROJS & WORK ORDERS DSGND BY DSGN MHRS/
                N11,TOTAL CONTR FUNDS OBLIGATED BY DSGN MHRS/
                N12,EEIC 52X FUNDS OBLIGATED BY DSGN MHRS/
                N13,M&R CONTR FUNDS OBLIGATED BY DSGN MHRS/
                N14,MC CONTR FUNDS OBLIGATED BY DSGN MHRS/
                N15,CWE PROJS DOCS COMPLETED BY PREP MHRS/
                N16,NBR PROJS DSGND BY DSGN MHRS/
                N17,NBR FAC SURVEYS COMPLETED BY SURVEY MHRS/
                N18,TOTAL NBR SPEC STUDIES BY MHRS/
                N19,TOTAL OA CONTR CHANGE ORDERS BY DSGN MHRS/
                N20,NBR CONTR CHANGE ORDERS BY DSGN MHRS/
                N21,CWE IH WORK ORDERS DSGND BY DSGN MHRS/
                N22,SVC CONTR FUNDS OBLIGATED BY PREP MHRS/
                N23,NBR EA & EIS COMPLETED BY PREP MHRS/
                N24,CWE A-E DSGN PKGS COMPLETED BY PREP MHRS/
                N25,A-E DSGN FUNDS OBLIGATED BY PREP MHRS/
                N26,NBR WORK ORDERS EVALUATED BY REVIEW MHRS/
                N27,NBR TECH REVIEWS COMPLETED BY REVIEW MHRS/
                N28,NBR MFH INSPECT COMPLETED BY INSPECT MHRS/
                N29,CWE PROJS & WORK ORDERS DSGND BY DSGN LBR COST/
                N30,TOTAL CONTR FUNDS OBLIGATED BY DSGN LBR COST/
                N31,EEIC 52X FUNDS OBLIGATED BY DSGN LBR COST/
                N32,M&R CONTR FUNDS OBLIGATED BY DSGN LBR COST/
                N33,MC CONTR FUNDS OBLIGATED BY DSGN LBR COST/
                N34,CWE PROJ DOCS COMPLETED BY PREP LBR COST/
                N35,NBR PROJS DSGND BY DSGN LBR COST/
                N36,NBR FAC SURVEYS COMPLETED BY SURVEY LBR COST/
                N37,TOTAL NBR SPEC STUDIES BY LBR COST/
                N38,TOTAL OA CONTR CHANGE ORDERS BY DSGN LBR COST/
                N39,NBR CONTR CHANGE ORDERS BY DSGN LBR COST/
                N40,CWE IH WORK ORDERS DSGND BY PREP LBR COST/
                N41,SVC CONTR FUNDS OBLIGATED BY PREP LBR COST/
```

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                 N42,NBR EA & EIS COMPLETED BY PREP LBR COST/
                 N43,CWE A-E DSGN FNDS COMPLETED BY PREP LBR COST/
                 N44,A-E DSGN FUNDS OBLIGATED BY PREP LBR COST/
                 N45,NBR WORK ORDERS EVALUATED BY REVIEW LBR COST/
                 N46,NBR TECH REVIEWS COMPLETED BY REVIEW LBR COST/
                 N47,NBR MFH INSPECT COMPLETED BY INSPECT LBR COST/
                 N48,FORMAL BCE PRODUCTIVITY PROGRAM NEEDED?
VALUE LABELS     N1 (1) MILITARY (2) CIVILIANS/
                 N2 (1) BASE CIVIL ENGINEER (2) CHIEF OF DESIGN
                 (3) CHIEF OF IE (4) OTHER/
                 N5 (1) HIGH SCHOOL (2) COLLEGE, NO DEGREE (3) ASSOCIATE'S DEGREE
                 (4) BACHELOR'S DEGREE (5) GRAD SCH, NO DEGREE
                 (6) MASTER'S DEGREE (7) DOCTORATE'S DEGREE (8) OTHER/
                 N6 (1)ADC (2) AFLC (3) AFSC (4) ATC (5) MAC
                 (6) SAC (7) TAC (8) SOA/
                 N8 (1) YES (2) NO/
                 N9 TO N48  (1) STRONGLY AGREE (2) AGREE (3) SLIGHTLY AGREE
                 (4) UNDECIDED (5) SLIGHTLY DISAGREE (6) DISAGREE
                 (7) STRONGLY DISAGREE
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                 (4.00 THRU HIGHEST=3)/
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                 (4.00 THRU 9.99=3)(10.00 THRU HIGHEST=4)
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PART IV

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2580 4 3 3 3 3 7 7 7 7 4 3 3 3 7 3 4 3 4 3 4 3 3 3 7
```

APPENDIX E

CODING SCHEMES

QUESTION NUMBER	VARIABLE NUMBER	VALUE	CODE
1	N1	Current Grade/Rank	(A) Colonel (B) Lt Colonel (C) Major (D) Captain (E) 1st Lieutenant (F) 2d Lieutenant (G) GS-9 (H) GS-10 (I) GS-11 (J) GS-12 (K) GS-13
2	N2	Current Position	(A) Base Civil Engineer (B) Chief, Design Sec- tior (C) Chief, Industrial Enginee 'ng Branch (D) Other
4	N4	Cumulative Length of Time (in any BCE unit)	(A) 0-0.99 Yrs (B) 1.00-3.99 Yrs (C) 4.00-9.99 Yrs (D) 10.00+ Yrs
5	N5	Education	(A) High school (B) College, no degree (C) Associate's degree (D) Bachelor's degree (E) Master's degree (F) Doctorate's degree (G) Other
6	N6	Major Command	(A) ADC (B) AFLC (C) AFSC (D) ATC (E) MAC (F) SAC (G) TAC (H) SOA

APPENDIX F

PARAMETRIC VALUES FOR VARIABLES N10 THROUGH N47

VARIABLE NUMBER	QUESTIONNAIRE NUMBER	MEDIAN	MEAN	STANDARD DEVIATION
N10	11a	3.089*	3.612	2.051
N11	11b	4.444	4.271	2.164
N12	11c	5.219	4.775	1.921
N13	11d	5.231	4.752	1.973
N14	11e	5.219	4.713	2.028
N15	11f	4.588	4.442	1.996
N16	11g	3.229*	3.744	2.173
N17	11h	4.588	4.442	1.996
N18	11i	4.273	4.279	2.084
N19	11j	4.844	4.496	2.118
N20	11k	4.947	4.636	2.023
N21	11l	4.720	4.326	2.077
N22	11m	4.000	4.186	2.150
N23	11n	4.625	4.465	2.088
N24	11o	3.636*	4.062	2.022
N25	11p	4.594	4.535	1.996
N26	11q	4.000	4.194	2.118
N27	114	4.154	4.194	2.058
N28	11s	5.333	4.674	2.096
N29	11t	3.692*	3.969	2.110
N30	11u	4.750	4.442	2.110
N31	11v	5.000	4.698	1.967
N32	11w	5.211	4.860	1.927
N33	11x	5.316	4.915	1.941
N34	11y	4.933	4.729	1.911
N35	11z	3.556*	3.984	2.172
N36	11aa	4.800	4.566	2.038
N37	11bb	4.679	4.558	2.019
N38	11cc	5.159	4.798	1.982

*Denotes useful measures

VARIABLE NUMBER	QUESTIONNAIRE NUMBER	MEDIAN	MEAN	STANDARD DEVIATION
N39	11dd	5.235	4.853	1.925
N40	11ee	4.647	4.481	2.066
N41	11ff	4.947	4.620	2.020
N42	11gg	5.118	4.744	2.001
N43	11hh	4.750	4.527	1.992
N44	11ii	5.316	4.961	1.897
N45	11jj	5.025	4.744	1.942
N46	11kk	4.917	4.636	1.948
N47	11ll	5.368	4.868	1.994

APPENDIX G

FREQUENCIES/HISTOGRAMS FOR USEFUL
PRODUCTIVITY MEASURES

PART I

VARIABLE N10: CWE PROJS & WORK ORDERS DSGND BY DSGN MHRS

CATEGORY LABEL	CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	CUM FREQ (PCT)
STRONGLY AGREE	1.	22	17.1	17.1
AGREE	2.	26	20.2	37.2
SLIGHTLY AGREE	3.	28	21.7	58.9
UNDECIDED	4.	7	5.4	64.3
SLIGHTLY DISAGREE	5.	12	9.3	73.6
DISAGREE	6.	18	14.0	87.6
STRONGLY DISAGREE	7.	16	12.4	100.0
	TOTAL	129	100.0	

```
CODE
      I
   1. **********************  (22)
      I   STRONGLY AGREE
      I
      I
   2. **************************  (26)
      I   AGREE
      I
      I
   3. ****************************  (28)
      I   SLIGHTLY AGREE
      I
      I
   4. *******  (7)
      I   UNDECIDED
      I
      I
   5. ************  (12)
      I   SLIGHTLY DISAGREE
      I
      I
   6. ******************  (18)
      I   DISAGREE
      I
      I
   7. ****************  (16)
      I   STRONGLY DISAGREE
      I
      I.........I.........I.........I.........I
      0        10        20        30        40
      FREQUENCY
```

PART II

VARIABLE N16: NBR PROJS DSGND BY DSGN MHRS

CATEGORY LABEL	CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	CUM FREQ (PCT)
STRONGLY AGREE	1.	25	19.4	19.4
AGREE	2.	22	17.1	36.4
SLIGHTLY AGREE	3.	24	18.6	55.0
UNDECIDED	4.	9	7.0	62.0
SLIGHTLY DISAGREE	5.	10	7.8	69.8
DISAGREE	6.	17	13.2	82.9
STRONGLY DISAGREE	7.	22	17.1	100.0
	TOTAL	129	100.0	

```
CODE
     I
  1. *************************  (25)
     I   STRONGLY AGREE
     I
     I
  2. **********************  (22)
     I   AGREE
     I
     I
  3. ************************  (24)
     I   SLIGHTLY AGREE
     I
     I
  4. *********  (9)
     I   UNDECIDED
     I
     I
  5. **********  (10)
     I   SLIGHTLY DISAGREE
     I
     I
  6. *****************  (17)
     I   DISAGREE
     I
     I
  7. **********************  (22)
     I   STRONGLY DISAGREE
     I
     I.........I.........I.........I.........I
     0        10        20        30        40
     FREQUENCY
```

PART III

VARIABLE N17: NBR FAC SURVEYS COMPLETED BY SURVEY MHRS

CATEGORY LABEL	CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	CUM FREQ (PCT)
STRONGLY AGREE	1.	17	13.2	13.2
AGREE	2.	16	12.4	25.6
SLIGHTLY AGREE	3.	34	26.4	51.9
UNDECIDED	4.	7	5.4	57.4
SLIGHTLY DISAGREE	5.	11	8.5	65.9
DISAGREE	6.	16	12.4	78.3
STRONGLY DISAGREE	7.	28	21.7	100.0
	TOTAL	129	100.0	

```
CODE
     I
  1. *****************  (17)
     I   STRONGLY AGREE
     I
     I
  2. ****************  (16)
     I   AGREE
     I
     I
  3. **********************************  (34)
     I   SLIGHTLY AGREE
     I
     I
  4. *******  (7)
     I   UNDECIDED
     I
     I
  5. ***********  (11)
     I   SLIGHTLY DISAGREE
     I
     I
  6. ****************  (16)
     I   DISAGREE
     I
     I
  7. ****************************  (28)
     I   STRONGLY DISAGREE
     I
     I.........I.........I.........I.........I
     0        10        20        30        40
     FREQUENCY
```

PART IV

VARIABLE N24: CWE A-E DSGN PKGS COMPLETED BY PREP MHRS

CATEGORY LABEL	CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	CUM FREQ (PCT)
STRONGLY AGREE	1.	15	11.6	11.6
AGREE	2.	17	13.2	24.8
SLIGHTLY AGREE	3.	31	24.0	48.8
UNDECIDED	4.	11	8.5	57.4
SLIGHTLY DISAGREE	5.	15	11.6	69.0
DISAGREE	6.	17	13.2	82.2
STRONGLY DISAGREE	7.	23	17.8	100.0
	TOTAL	129	100.0	

```
CODE
     I
  1. ***************  (15)
     I   STRONGLY AGREE
     I
     I
  2. *****************  (17)
     I   AGREE
     I
     I
  3. *******************************  (31)
     I   SLIGHTLY AGREE
     I
     I
  4. ***********  (11)
     I   UNDECIDED
     I
     I
  5. ***************  (15)
     I   SLIGHTLY DISAGREE
     I
     I
  6. *****************  (17)
     I   DISAGREE
     I
     I
  7. ***********************  (23)
     I   STRONGLY DISAGREE
     I
     I.........I.........I.........I.........I
     0        10        20        30        40
     FREQUENCY
```

PART V

VARIABLE N29: CWE PROJS & WORK ORDERS DSGND BY DSGN LB

CATEGORY LABEL	CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	CUM FREQ (PCT)
STRONGLY AGREE	1.	21	16.3	16.3
AGREE	2.	17	13.2	29.5
SLIGHTLY AGREE	3.	24	18.6	48.1
UNDECIDED	4.	13	10.1	58.1
SLIGHTLY DISAGREE	5.	14	10.9	69.0
DISAGREE	6.	17	13.2	82.2
STRONGLY DISAGREE	7.	23	17.8	100.0
	TOTAL	129	100.0	

```
CODE
     I
  1. *********************  (21)
     I   STRONGLY AGREE
     I
     I
  2. *****************  (17)
     I   AGREE
     I
     I
  3. ************************  (24)
     I   SLIGHTLY AGREE
     I
     I
  4. *************  (13)
     I   UNDECIDED
     I
     I
  5. **************  (14)
     I   SLIGHTLY DISAGREE
     I
     I
  6. *****************  (17)
     I   DISAGREE
     I
     I
  7. ***********************  (23)
     I   STRONGLY DISAGREE
     I
     I.........I.........I.........I.........I
     0        10        20        30        40
     FREQUENCY
```

PART VI

VARIABLE N35: NBR PROJS DSGND BY DSGN LBR COST

CATEGORY LABEL	CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	CUM FREQ (PCT)
STRONGLY AGREE	1.	21	16.3	16.3
AGREE	2.	20	15.5	31.8
SLIGHTLY AGREE	3.	23	17.8	49.6
UNDECIDED	4.	9	7.0	56.6
SLIGHTLY DISAGREE	5.	14	10.9	67.4
DISAGREE	6.	16	12.4	79.8
STRONGLY DISAGREE	7.	26	20.2	100.0
	TOTAL	129	100.0	

```
CODE
          I
    1.    *********************  (21)
          I   STRONGLY AGREE
          I
          I
    2.    ********************  (20)
          I   AGREE
          I
          I
    3.    ***********************  (23)
          I   SLIGHTLY AGREE
          I
          I
    4.    *********  (9)
          I   UNDECIDED
          I
          I
    5.    **************  (14)
          I   SLIGHTLY DISAGREE
          I
          I
    6.    ****************  (16)
          I   DISAGREE
          I
          I
    7.    **************************  (26)
          I   STRONGLY DISAGREE
          I
          I.........I.........I.........I.........I
          0        10        20        30        40
          FREQUENCY
```

APPENDIX H

OPEN-ENDED RESPONSES TO SURVEY QUESTION 13 -- ADDITIONAL PRODUCTIVITY MEASURES AND COMMENTS CONCERNING PRODUCTIVITY MEASUREMENT

The only additional productivity measures suggested by the respondents which did not duplicate measures covered in the questionnaire were in the form of the alternate method of productivity measurement as described in Chapter 2, Literature Review. That is, a ratio of actual manhours expended to estimated manhours. Since the accuracy of manhour estimates is questionable, this method of measurement does not appear to be practical at present; however, the alternate method of productivity measurement should be considered in some future study.

The comments made by the respondents concerning productivity measurement in the design section were categorized as follows:

1. Other variables internal to the design section such as the complexity of projects, experience of the engineers, engineering discipline (i.e., civil, mechanical, electrical), and type of project need to be considered (N = 23).

2. The decision to use/not use the productivity measures developed should be made by the base level managers. A formal program could be counterproductive since the costs of implementing and controlling the program and reporting the results may outweigh the benefits gained. Also, with a formal program, commanders may make judgments based on the

productivity measures rather than trusting in the professionalism of the engineers (N = 20).

3. The productivity of professionals such as engineers should not be measured since the quality of support of base missions is a more important consideration than achieving a quantitative standard (N = 17).

4. Other duties of design section personnel such as briefings, training sessions, staff meetings, consultant services, and military requirements (i.e., commander's call, squadron duties, Air Force Assistance Fund, Air Force Association) need to be measured (N = 14).

5. The design section operates in a dynamic environment and the influence of external variables (i.e., project funding, command interest, higher headquarters directives) which are beyond the control of this section make productivity measurement questionable, if not useless (N = 13).

6. Productivity measurement should be kept simple; one good measure is all that is needed (N = 3).

7. Labor cost is a poor input measure since personnel with similar jobs and experience often receive different salaries (N = 3).

8. Labor cost is a better input measure than man-hours since higher graded/salaried personnel should be expected to produce at a higher rate than the less experienced, lower paid personnel (N = 2).

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